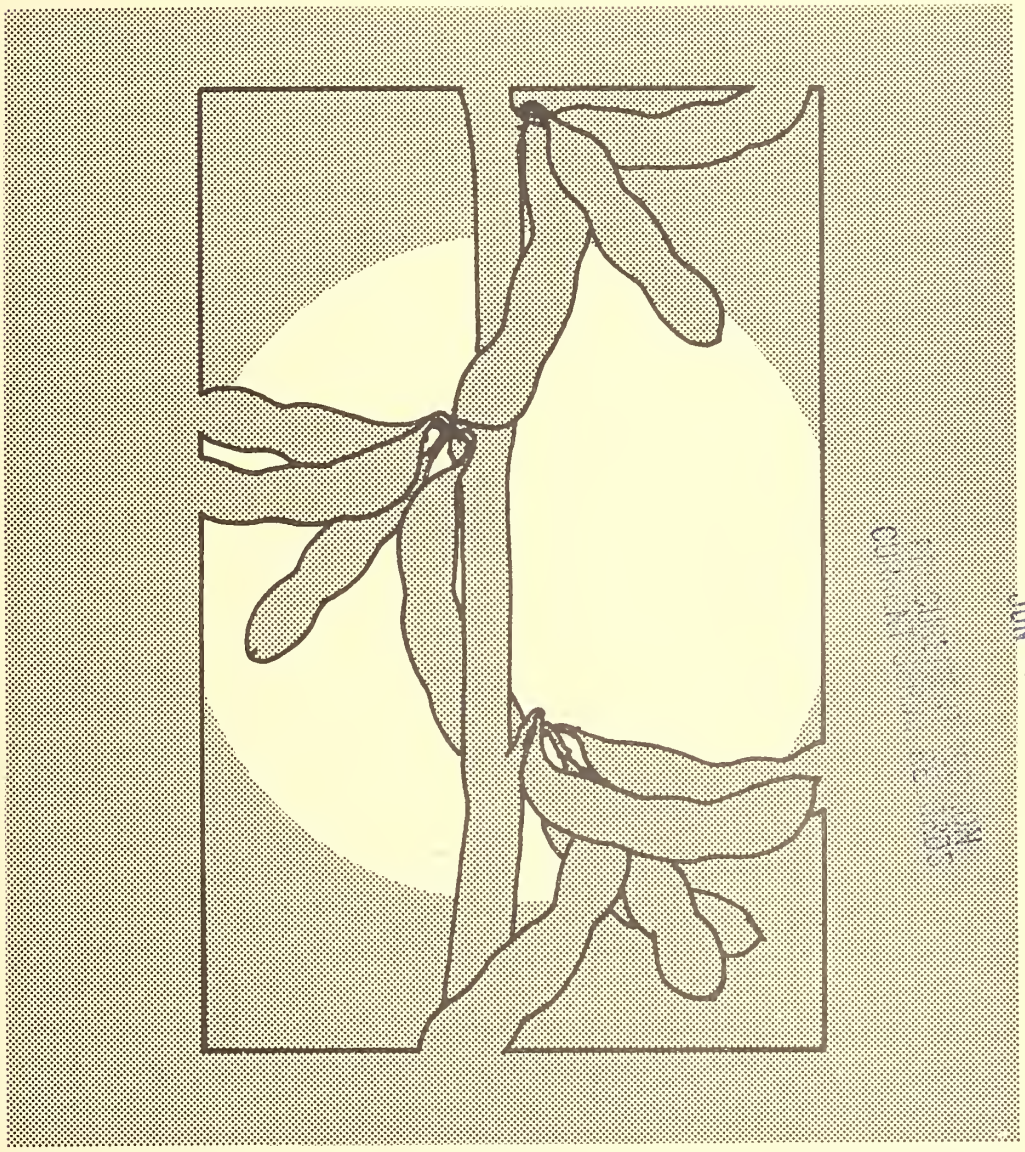
# Soybean Genetics Newsletter





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**The data presented here are not to be used in publications without the consent of the respective authors.**

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# I. FOREWORD

The Soybean Genetics Newsletter (SGN) had a successful first volume. Its favorable reception inspired a measure of confidence. The quality of contributions for Volume 2 is again impressive and will contribute to our future growth. Our mailing list totals about 400 and the number of interested scientists is increasing.

In response to a number of requests, we have added a new section to Volume 2. Section VIII reports research activities of soybean workers, listed alphabetically by country, and then for the U.S., alphabetically by state.

Suggestions for improvement of the SGN will be appreciated. It is our belief that the SGN should be kept as informal as possible and that it should serve as a means of communication at the international level.

Publication of the SGN is no small task and we wish to express our sincere thanks to Hollys Heer for her efficient and competent services. The voluntary assistance of Marc Albertsen, Linda Martin, Eke Meister, Monica Sheridan, and Carol Winger is gratefully acknowledged.

## ACKNOWLEDGEMENTS

We wish to express our appreciation to the National Soybean Processors Association, whose grant made this issue of the Newsletter possible. We are grateful to Robert W. Judd of the National Soybean Crop Improvement Council for his encouragement and support.

R. G. Palmer

## II. ANNOUNCEMENT

1. World Soybean Research Conference.

The World Soybean Research Conference is scheduled to be held at the University of Illinois, Urbana, Illinois August 3-8, 1975. The program will encompass both production and marketing-utilization aspects of soybean research. We ask that potential participants advise Dr. R. W. Howell, so that they will be on a more specific mailing list for the conference.

Dr. R. W. Howell, Head
Department of Agronomy
University of Illinois
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# III. REPORT OF SOYBEAN GENETICS COMMITTEE

A. The current members of this committee are:

R. L. Bernard (Chairman)
USRSL
Davenport Hall
Urbana, IL 61801

R. I. Buzzell
Agr. Canada, Res. Station
Harrow, Ontario, NOR 1GO
Canada

R. L. Cooper
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University of Florida
Gainesville, FL 32611

R. G. Palmer, USDA
Agronomy Department
Iowa State University
Ames, IA 50010

B. The duties of this Committee were reviewed at Urbana, Illinois March 3, 1975, and the following procedures were retained:

1. Maintain Genetic Collection.

The Genetic Collection is divided into four categories:

a. Type Collection includes all published genes of soybeans, preferably in the original strains (excluding U.S. and Canadian name varieties, which are maintained in a separate collection) plus certain mutants or strains that appear to the Committee to have potential genetic interest.

b. Isoline Collection includes adapted varieties Clark, Harosoy and Lee, into which have been backcrossed single genes or combinations of genes. Also included are certain genes or combinations with Chippewa, Wayne, and Williams.

c. Linkage Collection includes linkage combinations and the various genetic recombinations.

d. Cytological Collection includes translocations, inversions, deficiencies, trisomics, tetraploids, etc.

Collections a, b, and c are maintained at Urbana, Illinois, with R. L. Bernard as curator. Collection d is maintained at Ames, Iowa, with R. G. Palmer as curator.

C. Manuscript review and genetic symbol approval.

The Soybean Genetics Committee requests that researchers submit all manuscripts involving genetic symbols to the Committee Chairman R. L. Bernard. This review by the Genetics Committee will serve to avoid conflict of symbols and will help to insure orderly identification and use of genetic nomenclature. This will also allow assignment of type collection designations (T-numbers) prior to publication, so that these T-numbers may be used in the journal article to identify parental lines.

D. Soybean Genetics Newsletter notes.

All notes for the Newsletter should be sent to R. G. Palmer, who will ask the Soybean Genetics Committee to review those articles that concern genetic symbols. These symbols, reported in the Newsletter, will have the same status as those published in scientific journals.

E. Rules for genetic symbols.

The rules for genetic symbols appeared in the Soybean Genetics Newsletter 1: 5-8. The Soybean Genetics Committee requests that researchers with manuscripts involving genetic symbols, either for scientific journals or the Soybean Genetics Newsletter, follow these rules.

# IV. RESEARCH NOTES FROM COOPERATORS

ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER
Shanhua, Tainan, Taiwan

## 1. The soybean improvement program at the Asian Vegetable Research and Development Center.

In 1971, the Asian Vegetable Research and Development Center (AVRDC) was created as an international research organization responsible for improving the production and nutritional quality of vegetable crops in the humid tropics. The Center is located to the north of Tainan City in southern Taiwan (between 23°07'07" and 23°06'36" north latitude, and between 120°16'45" and 120°17'28" east longitude at an elevation of nine meters AMSL).

In March 1973, AVRDC selected the soybean as one of the six crops to receive initial emphasis in its research program.

The goal of AVRDC's soybean improvement program is to develop and select varieties that are especially well adapted to the tropics and subtropics, where too few soybeans are grown today and where yields on farmers' fields are low.

Currently, our soybean research is focused on: (1) exploring the factors limiting the soybean's yield potential in the humid tropics; (2) studying the effects of different photoperiods which limit the adaptability of the soybean; and (3) breeding for multiple disease resistance.

Our first activity was to collect germplasm from around the world. To date we count 5133 cultivars from 42 different countries in our world collection. We, of course, are most interested in increasing our collection and welcome any assistance from fellow breeders in this aspect.

Yield trials of our elite selections have indicated the possibility of obtaining yields of around seven tons per hectare under our conditions at Shanhua. Further experimentation is in progress to confirm this high yield potential.

Our opinion is that the tropical soybean should have low photoperiod sensitivity, and should not flower too early in hot weather (some varieties

when grown in the tropics start flowering before they have developed sufficient vegetative growth to produce a satisfactory crop). From a field screening of 2041 accessions, we tentatively identified 505 cultivars as photoperiod insensitive. Further screening identified 168 accessions as photoperiod insensitive in both the spring and fall seasons.

Accessions carrying resistance or different degrees of tolerance to soybean rust, SMV, bacterial pustule, downy mildew, purple seed stain, and root-knot disease have been identified through field screening under natural infection. In some cases, resistance has been confirmed in the greenhouse with artificial inoculation.

Our hybridization program to combine resistance to the various diseases with a high yield potential has produced a number of highly promising selections which are presently in the $F_4$ and $F_5$ generations. Nearly 10,000 single plants from over 800 different cross combinations have been advanced in this program.

During 1974 we sent out 4719 cultivars, as well as 11 selections in the $F_3$ generation, and 340 in the $F_4$, to 33 scientists in 21 countries. We hope to expand our scientist-to-scientist outreach activities considerably in the future. We have also sought to cooperate fully with INTSOY and the other international agricultural research centers to better meet our common goal to produce more food for mankind.

An annual report is published every year (1974's will be ready in July); you are welcome to write AVRDC's Office of Information Services to be included in our mailing list.

Specific germplasm or early and advanced segregating populations (or both) are available to fellow researchers. You may direct your correspondence and requests to:

S. Shanmugasundaram
AVRDC, P.O. Box 42
Shanhua, Tainan (741)
Taiwan

AGRICULTURE CANADA
Research Station
Harrow, Ontario

1. Powdery mildew of soybeans.

Powdery mildew was introduced into a Station greenhouse in 1968, apparently with seed of Glycine falcata (PI 246.591). This accession was very susceptible; there was abundant conidia production. The mildew spread to G. max and, before control measures could be instituted, varietal differences in resistance and susceptibility were observed. Thus, we proceeded to screen cultivars, strains, and segregating material from 1969 through 1973 whenever space was available. In addition to the inoculum that was generally present in the greenhouse, the seedlings were dusted with conidia from diseased plants that had been stored or were growing in the greenhouse. Any susceptible breeding material being grown in the greenhouse was treated with a fungicide.

Disease readings were taken after the fungus had become established and was producing conidia abundantly on susceptible plants that were at least a month old. Thus, conidial sporulation, to a large degree, was our measure of susceptibility. In 1973 we discovered that it was possible to rate certain resistant varieties as being susceptible, if readings were based on the presence of mycelial growth which was limited to trace or small amounts confined chiefly to the first and second trifoliolates, and which was ephemeral without abundant sporulation. This was not unusual, since Luttrell and Samples (1954) observed a trace of mildew on 'Roanoke' soybeans which we rated as resistant, and Demski and Phillips (1974) observed trace amounts on a number of cultivars in the greenhouse. During our study, any cultivars or strains that gave doubtful or inconsistent readings were retested to obtain results based on the presence or absence of abundant mycelia and conidia; these reactions we now consider to be adult susceptibility and resistance.

Examination of perithecia, which were occasionally observed 6 to 9 weeks after inoculation, showed that the causal agent was Microsphaera. In testing the cultivars used by Lehman (1947), we obtained the same resistant and susceptible reactions that he did with Microsphaera. Furthermore, a test of Lupinus angustifolius L. agreed with Luttrell and Samples (1954), who reported

that blue lupines were highly susceptible to M. diffusa. When inoculated with powdery mildew conidia from soybeans, 'Bitter Blue' and 'Borre Sweet Blue' gave highly susceptible reactions, i.e., defoliation occurred and abundant perithecia were formed. M. diffusa has been reported on Korean lespedeza, Lespedeza stipulacea Maxim, by Johnson et al. (1940); 'Rowan', which is resistant to powdery mildew (see Review of Applied Mycology 32: 177; 1953), was resistant to powdery mildew in our tests. Although M. diffusa, which Paxton and Rogers (1974) reported as the causal agent of soybean powdery mildew, was involved, it is possible that Erysiphe pisi DC, which causes powdery mildew of Pisum sativum L., could also have been present. When inoculated with conidia from soybean plants, pea lines carrying the er gene for resistance were resistant and 'Alaska' was susceptible. Perithecia formed on Alaska were typical of E. pisi.

We used conidia from 'Chippewa 64' (which carries adult resistance) and obtained mildew on Alaska peas grown in isolation. However, we were unsuccessful in reestablishing mildew on Chippewa 64 using conidia from Alaska. Thus, although there is a dominant soybean gene involved in adult resistance (results are being published elsewhere), and there appears to be a recessive gene involved in juvenile resistance (which we are studying further), our statement in Soybean Genetics Newsletter 1: 9-10 regarding M. diffusa and E. pisi appears to be in error. Races of the fungus may be involved, and there is the possibility that "microsphaera" and "erysiphe" types may exist within one species. Homogeneous cultures should be tested on a number of species. During our study we observed only resistant reactions for 4 accessions of G. clandestina, and for 15 of G. wightii, whereas G. soja, G. tabacina and G. tomentella each contained resistant and susceptible accessions.

Because powdery mildew of soybeans has not been important in the field, there has been no selection for resistance by breeders. Thus, resistant and susceptible cultivars occur at random, depending on the genotypes of the parents. As can be seen in Table 1, resistant and susceptible cultivars are distributed over the Maturity Groups 00 to IV; however, Maturity Group II appears especially vulnerable, with a high proportion of susceptible cultivars. Mildew reactions for adult resistance and susceptibility are also given in the Uniform Soybean Test Reports (Northern States) for 1970 through 1974.

Table 1

Some common cultivars in Maturity Groups 00 to IV that are either adult-resistant (R) or susceptible (S) to powdery mildew

| Maturity group | | Resistant and susceptible cultivars |
|---|---|---|
| 00 | R | Ada, Altona, Morsoy |
| | S | Norman |
| 0 | R | Evans, Merit, Swift, Traverse, Vansoy, Wilkin |
| | S | Clay, Hardome |
| I | R | Anoka, Chippewa 64, Dunn, Rampage, Wirth |
| | S | Disoy, Hark, Hodgson, Steele |
| II | R | Beeson, Lindarin 63, Provar |
| | S | Amsoy 71, Corsoy, Harosoy 63, Harwood, Magna, Prize, Wells |
| III | R | Adelphia, Calland, Wayne, Williams |
| | S | Kanrich |
| IV | R | Bethel, Clark 63, Cutler 71, Delmar, Kent, Wye |
| | S | Bonus |

References

Demski, J. W. and D. V. Phillips. 1974. Reactions of soybean cultivars to powdery mildew. Plant Dis. Rep. 58: 723-726.

Johnson, H. W., C. L. Lefebvre and T. T. Ayers. 1940. Phytopathology 30: 620-621.

Lehman, S. G. 1947. Powdery mildew of soybean. Phytopathology 37 (abstr.): 434.

Luttrell, E. S. and J. W. Samples. 1954. Mildew of lupines caused by Microsphaera diffusa. Plant Dis. Rep. 38: 719-720.

Paxton, J. D. and D. P. Rogers. 1974. Powdery mildew of soybeans. Mycologia 66: 894-896.

R. I. Buzzell
J. H. Haas

2. Soybean linkage tests.

$F_2$ linkage results are presented in Table 1 with a = XY, b = Xy, c = xY, and d = xy for the gene pairs listed in the form of Xx and Yy. Percentage recombination was obtained as previously (Buzzell, 1974). In the case of $\underline{E}_3\underline{e}_3$, the $F_2$ was classified on the basis of $F_3$ progeny tests.

Recombinants between $\underline{W}_1\underline{w}_1$ and Wmwm were not recovered, even though the $\underline{w}_1\underline{w}_1$wmwm crossover type had been obtained previously (Buzzell, Bernard and Buttery, 1974). The $F_2$ seeds had been in controlled environment storage for a few years; the stand was only 66%, which could have skewed the data. The $F_2$ of $\underline{w}_1\underline{w}_1$wmwm X Beeson will be tested for linkage in 1975.

Weiss (1970) reported a recombination value of 26.4% for $\underline{p}_2$ and ln. He used T31 ($\underline{p}_2$Ln) as a parent in repulsion crosses. My T31 is not markedly narrow-leafed but the $F_2$ of T31 X OX936 (broad leaflets) segregated broad and narrow. The $F_1$'s of T31 X T41, T31 X T109, and T31 X T204 were narrow, indicating that my strain of T31 carries ln. The recombination estimate of 44% is much higher than that obtained by Weiss. Progeny tests for leaf shape showed that there were no misclassifications in the pubescent $F_2$ classes but that there were some in the puberulent classes. Since a few of the puberulent $F_2$ plants did not produce seed, the recombination value could still be biased. I had difficulty in rating the leaf type of puberulent plants because the absence of pubescence seemed to affect the expression of narrow leaves even in the greenhouse where there was no leafhopper damage. The possibility of a pleiotropic effect of $\underline{p}_2$ on leaf shape will be explored.

Table 1

Soybean $F_2$ linkage tests

| Genes | | a | b | c | d | Sum | %R | SE | Phase* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L62-904 ($\underline{w}_1$Wm) X T235 ($\underline{W}_1$wm) | | | | | |
| $\underline{W}_1\underline{w}_1$ | Wmwm | 778 | 379 | 387 | 0 | 1544 | 0 | | R |
| | | | | T31 ($\underline{p}_2$ln) X OX936 ($\underline{P}_2$Ln) | | | | | |
| $\underline{P}_2\underline{p}_2$ | Lnln | 213 | 53 | 65 | 25 | 356 | 44.0 | 3.7 | C |

Table 1 (continued)

| Genes | | a | b | c | d | Sum | %R | SE | Phase* |
|---|---|---|---|---|---|---|---|---|---|
| | | T245 ($\underline{T}_1\underline{w}_1\underline{ep}$) X Raiden ($\underline{t}_1\underline{W}_1\underline{Ep}$) | | | | | | | |
| $\underline{W}_1\underline{w}_1$ | $\underline{T}_1\underline{t}_1$ | 138 | 46 | 42 | 15 | 241 | 51.0 | 4.8 | R |
| $\underline{W}_1\underline{w}_1$ | $\underline{Epep}$ | 142 | 42 | 45 | 10 | 239 | 54.0 | 5.1 | C |
| $\underline{Epep}$ | $\underline{T}_1\underline{t}_1$ | 141 | 45 | 39 | 14 | 239 | 51.8 | 4.8 | R |
| | | Cloud ($\underline{w}_1\underline{Fg}_1\underline{fg}_2$) X Harman ($\underline{W}_1\underline{fg}_1\underline{Fg}_2$) | | | | | | | |
| $\underline{W}_1\underline{w}_1$ | $\underline{Fg}_1\underline{fg}_1$ | 76 | 22 | 34 | 9 | 141 | 49.0 | 6.4 | R |
| $\underline{W}_1\underline{w}_1$ | $\underline{Fg}_2\underline{fg}_2$ | 72 | 26 | 33 | 10 | 141 | 52.0 | 6.4 | C |
| $\underline{Fg}_1\underline{fg}_1$ | $\underline{Fg}_2\underline{fg}_2$ | 81 | 29 | 24 | 7 | 141 | 47.0 | 6.5 | R |
| | | Evans ($\underline{e}_3\underline{w}_1$) X OX27-8 ($\underline{E}_3\underline{W}_1$) | | | | | | | |
| $\underline{W}_1\underline{w}_1$ | $\underline{E}_3\underline{e}_3$ | 137 | 46 | 40 | 14 | 237 | 49.5 | 4.8 | C |

*R = repulsion; C = coupling.

References

Buzzell, R. I. 1974. Soybean linkage tests. Soybean Genet. Newsl. 1: 11-14.

Buzzell, R. I., R. L. Bernard and B. R. Buttery. 1974. Inheritance of magenta flower color. Soybean Genet. Newsl. 1: 14-15.

Weiss, M. G. 1970. Genetic linkage in soybeans. Linkage Group IV. Crop Sci. 10: 368-370.

R. I. Buzzell

UNIVERSITY OF ILLINOIS
Department of Agronomy
Urbana-Champaign, Illinois

1. Soybean germplasm data bank.

A soybean germplasm data bank has been set up by members of the Department of Agronomy at the University of Illinois, Urbana-Champaign. Information on named soybean varieties, Plant Introductions, Genetic Type Collection lines, Forage Collection varieties, and species collections, has been compiled and

computerized so that it is readily available as a reference source. An information retrieval system enables queries concerning various aspects of the germplasm bank to be answered with a minimum of human effort. The data bank is constantly being updated as new information regarding old varieties is released; and as new varieties appear, they are added to the list.

Consequently, we would be grateful for any information resulting from screening of the germplasm, particularly with regard to disease and insect resistance, physiological and morphological characteristics, which could be entered into the computer data bank and increase its usefulness.

Correspondence concerning germplasm screening, and requests for queries of the data bank on specific items of information, should be addressed to Dr. T. Hymowitz, c/o Dr. C. A. Newell, Department of Agronomy, University of Illinois, Urbana, IL 61801, U.S.A.

T. Hymowitz
C. A. Newell

G. B. PANT UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
Department of Plant Breeding
Pantnagar (Nainital) U.P., India

1. Cytological abnormalities associated with male sterility genes in soybean.

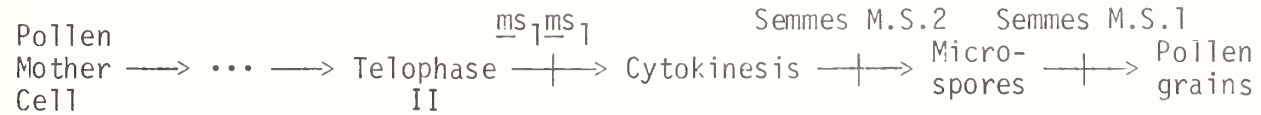
Singh et al. (1974) reported the inheritance as well as the pollen behaviour of 3 male-sterile lines of soybean, viz: 'Semmes M.S.1', 'Semmes M.S.2' and 'N 69-2774'. They observed monogenic inheritance with sterility being the recessive trait in all these lines. Semmes M.S.1 had nonfunctional pollen but of the same size as that of normal pollen grains; Semmes M.S.2 had no pollen at all, whereas N 69-2774 had nonfunctional pollen but these were much bigger as compared to the normal pollen grains. The present study was undertaken to elucidate the cytological basis for the differential pollen behaviour of these male-sterile lines.

Male-sterile plants from the segregating progeny rows of each of these lines were identified by microscopic examination of the pollen grains at initiation of flowering. Young buds from the male-sterile plants were fixed in

acetic-alcohol fixative for 24 hours and then transferred to 70% alcohol. Acetocarmine squashes were prepared to study the meiotic stages.

The cytological studies revealed specific abnormalities in these lines. Semmes M.S.1 showed normal cytokinesis and normal microspore formation but the microspores failed to develop into normal pollen grains. Consequently nonfunctional pollen grains were observed. Normal cytokinesis was observed in Semmes M.S.2 also, but the daughter nuclei degenerated immediately thereafter and no microspores or pollen grains could be observed. In N 69-2774, there was a complete failure of cytokinesis after telophase II and, thus, the 4 daughter nuclei remained together and got encapsulated within a single pollen wall, resulting in a single large size nonfunctional pollen grain.

Apparently, the manifestation of the sterility genes in these lines is quite different. The mutant gene blocks the normal cytokinesis in N 69-2774; it blocks the microspore formation in Semmes M.S.2, whereas in Semmes M.S.1 it blocks one of the steps involved in normal pollen development from microspores. Obviously, the genes for sterility appear to be different in these lines. The gene symbol '$\underline{ms}_1\underline{ms}_1$' has been assigned for N 69-2774 (Brim and Young, 1971). [Further genetic studies are in progress, on completion of which gene symbols will be proposed for Semmes M.S.1 and Semmes M.S.2, and sent to the Soybean Genetics Committee for consideration. Editor's note.] The order and the probable place of action of these genes during meiosis and pollen development may be as indicated below:

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Singh, B. B., S. C. Gupta and B. D. Singh. 1974. Induced male-sterile mutants in soybeans. Soybean Genet. Newsl. 1: 19-20.

A. B. Patil

B. B. Singh

INTERNATIONAL SOYBEAN PROGRAM (INTSOY)
UNIVERSITY OF ILLINOIS, Department of Agronomy
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1. Daylength sensitivity studies with Maturity Group III soybean germplasm.*

All available soybean genotypes of Maturity Group III (515 lines) from the USDA soybean germplasm collection were evaluated for degree of daylength sensitivity at Urbana, Illinois, during the summer of 1973.

Each genotype (planted May 19) was grown in four-plant hills, spaced 24 x 40 inches, under both natural daylength and natural daylength extended by 5 hrs incandescent lighting. The incandescent lights were placed 5 feet above ground surface and provided illumination during the night period in the intensity range of 5 to 10 ft-c (50 to 100 lux). Lights were turned on from 10:30 p.m. to 3:30 a.m. beginning June 6. Frost terminated the experiment at 172 days after planting. The number of days from planting to first flower and to maturity were compared for the two treatments. The photoperiodic sensitivity of each soybean genotype was measured by the delay or lack of delay of flowering and maturity by the extended photoperiod.

The data show extreme variation in daylength sensitivity in Group III germplasm. The difference in flowering date between natural and extended photoperiod ranged from 2 to 60 days. The majority (325 out of 515) were delayed from 21 to 40 days. No genotype was delayed more than 60 days, but only seven were delayed less than 10 days. Only 25 of the 515 genotypes matured before killing frost, and of these, 24 were delayed from 25 to 52 days. The remaining one, PI 317.334B, showed a high degree of insensitivity to the extended daylength. It flowered 2 days earlier and matured 3 days earlier under the extended daylength.

PI 317.334 was introduced to Ames, Iowa, as 'Kitami-Shiro' in 1966 from Hokkaido National Experimental Station, Sapporo, Japan. It was grown for line purification at Urbana in 1967. One plant matured several days later than the majority of the row and was harvested separately and designated B.

*This study is supported by a 211(d) grant from USAID.

The A line from a plant typical of the variety is classified in Maturity Group II while the B line is in Group III.

Group III germplasm was also screened at the Isabela substation, College of Agricultural Sciences, University of Puerto Rico, from July 1974 to February 1975. Incandescent lighting was timed to provide continuous lighting and the experiment was terminated at 235 days from planting. Results were similar to the Urbana trial. The sister line, PI 317.334A and one of its parental lines, PI 196.160 (Ooyachi-2), were screened and also found to be day neutral. PI 317.334B also expressed a low degree of photoperiod sensitivity when grown in controlled environment chambers under photoperiods of 12, 14, 16, and 20 hours. The inheritance of the photo-insensitivity of PI 317.334B is being investigated.

C. R. Nissly
R. L. Bernard — USDA
C. N. Hittle

IOWA STATE UNIVERSITY
Department of Agronomy
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UNITED STATES DEPARTMENT OF AGRICULTURE
Ames, Iowa

## 1. The nature of sterility in the $\underline{ms}_1$ male-sterile mutant.*

The male-sterile (female-fertile) mutant $\underline{ms}_1$ is identified by three characteristic features. Kenworthy *et al.* (1973) reported occurrence of twin seedlings, at a low frequency. We are reporting the two additional characteristics: failure of cytokinesis following telophase II; and production of twice as many pollen mother cells as are found in male-fertile sibs.

In meiosis, normal chromosome pairing and separation occurred in both male-sterile plants and fertile plants. The male-sterile plants, however, showed a failure of cytokinesis after telophase II, resulting in 4-nucleated "pollen grains", which were nonfunctional and eventually degenerated.

*Research supported in part by a grant from the American Soybean Association Research Foundation.

Microscopic examination of cross sections of paraffin-embedded anthers revealed that both male-sterile plants and fertile plants had four locules per anther. Longitudinal serial sections of anthers from male-sterile plants showed twice as many pollen mother cells per locule as were found in fertile plants. The pollen mother cells were approximately the same size in both types. The anthers from male-sterile plants were larger, to accommodate the additional pollen mother cells. Because pollen mother cells from male-sterile plants do not undergo cytokinesis, there are only as many "pollen grains" as pollen mother cells. In the fertile plants, however, four pollen grains come from each pollen mother cell. The ratio of pollen grains per locule in a male-sterile plant as compared to that in a fertile plant was 2:4 rather than the expected 1:4.

References

Kenworthy, W. J., C. A. Brim and E. A. Wernsman. 1973. Polyembryony in soybeans. Crop Sci. 13: 637-639.

Reid G. Palmer — USDA
Marc C. Albertsen

## 2. Three independent male-sterile mutations at the $ms_1$ locus.*

In our soybean genetics program, we had observed that pollen from an off-type plant in T258 was large, dark-staining and seemed to have characteristics similar to pollen produced by $ms_1$ plants (Palmer, 1974). This line is called the Ames male-sterile. We received from the U.S. Regional Soybean Laboratory, Urbana, IL 61801, seeds of two lines segregating for sterility. The sterile plants in both lines had large, dark-staining pollen grains. One line, from R. L. Cooper, is called the Urbana male-sterile (Cooper and Boerma, 1975). The other line, from R. L. Bernard, had been found in a commercial field of 'Harosoy' in 1955 and is called the Harosoy male-sterile. The Ames, Urbana, and Harosoy lines are considered to be male-sterile because: (1) they were ineffective as male parents in cross-pollinations (or self-pollinations); and (2) they exhibited some female fertility, although lower than fertile sib plants.

*Research supported in part by a grant from the American Soybean Association Research Foundation.

We made the appropriate allelism tests among the four mutants: $\underline{ms_1}$, Ames, Urbana, and Harosoy male-steriles (Table 1). The tests were made using known heterozygotes as male parents onto homozygous recessive female parents. The testcrosses were evaluated in both $F_1$ and $F_2$ generations. All testcross combinations approximated a 1:1 ratio of fertile:sterile plants, with the steriles having large, dark-staining pollen grains. Only a few fertiles have been tested in the $F_2$ generation, but all gave good approximations to a 3 fertile:1 sterile ratio. The evidence from the testcrosses and $F_2$ segregations strongly supports the hypothesis that the Ames, Urbana, and Harosoy male-steriles are at the same locus as the $\underline{ms_1}$ mutant. From the data in Table 1, we cannot distinguish whether we have the same allele at the $\underline{ms_1}$ locus or if we have a multiple allelic series.

We are making additional testcrosses and will evaluate $F_2$ progenies for the ratio of fertile:sterile plants. In addition, we will be evaluating the Ames, Urbana, and Harosoy male-steriles for: (1) the occurrence of twin seedlings; (2) the number of pollen mother cells produced; and (3) the failure of cytokinesis following meiosis II. (See Palmer and Albertsen, 1975.)

Table 1

Male-sterile allelism tests

| Female parent* | Male parent* | Number of $F_1$ plants | |
|---|---|---|---|
| | | Fertile | Sterile |
| $\underline{ms_1}\underline{ms_1}$ | AMS | 2** | 3** |
| AMS | $\underline{Ms_1}\underline{ms_1}$ | 6 | 6 |
| UMS | AMS | 4 | 5 |
| UMS | $\underline{Ms_1}\underline{ms_1}$ | 6 | 4 |
| HMS | $\underline{Ms_1}\underline{ms_1}$ | 2 | 1 |
| HMS | AMS | 2 | 1 |

*In this note for the Soybean Genetics Newsletter we have called the mutants: AMS (Ames male-sterile); HMS (Harosoy male-sterile); and UMS (Urbana male-sterile). Female parents were male-sterile plants; male parents were known heterozygotes.

**Includes twin seedling (one member fertile; other member sterile).

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3. Inheritance and derivation of T225H, $\underline{Y}_{18}\underline{y}_{18}$.

In a cross of the cultivar 'Lincoln' (female parent) by a yellow plant of T225, $\underline{y}_{18}$, (male parent), the $F_1$ was green. In the $F_2$, we had segregation of 3 green plants:1 yellow plant (Table 1), satisfying the hypothesis that $\underline{y}_{18}$ is a single recessive gene.

Crosses of T225 (yellow branch on a variegated plant) by 'Clark 63' (male parent) were obtained. T225 has white flowers; Clark 63 has purple flowers. The two $F_1$'s were green with purple flowers, and in the $F_2$ we had good fits to the expected 9:3:3:1 segregation for plant color and flower color (Table 1). There was no indication of linkage of plant color with flower color. Further indication of independent assortment of two genes was evidenced by segregation of $F_2$ families in a 1:2:2:4:1:2 ratio.

The data in Table 1 show that $\underline{y}_{18}$ is a single genetic trait and is inherited as a single Mendelian recessive.

While it is possible to obtain $\underline{Y}_{18}\underline{y}_{18}$ plants among the progeny of $\underline{Y}^{m}_{18}\underline{y}_{18}$, we have circumvented the use of variegated plants by using a yellow plant in a cross with a green sib. As a result of cross 1, we have $\underline{y}_{18}$ present in the heterozygous state, $\underline{Y}_{18}\underline{y}_{18}$, in its original background, the cultivar Lincoln. We can now produce many yellow plants and green plants without the presence of the variegated plants. The yellow plants may prove useful in biochemical and developmental studies.

We believe this genetic combination, $\underline{Y}_{18}\underline{y}_{18}$, should be maintained, either from the above-mentioned cross or by selection from a mutated T225. This new type is designated T225H* while the original line, T225, is maintained

*For T-strains with an H suffix (e.g., T225H), the gene is carried as the heterozygote because the homozygous mutant is lethal, sterile, or very weak.

as the mutable form $\underline{Y}^{m}_{18}$. Since T225H is lethal under field conditions, it needs to be maintained as the heterozygote. Seed of T225H has been deposited with R. L. Bernard, U.S. Regional Soybean Laboratory, Urbana, IL 61801.

Table 1

Genetic crosses made to determine the inheritance of $\underline{y}_{18}$

| Cross number | Female parent | Male parent | Genotype of $F_1$ | $F_2$ segregation ratio Expected | Observed | $\chi^2$ |
|---|---|---|---|---|---|---|
| 1 | Lincoln | T225[a] | Yw | 3Yw | 31 | 0.13 |
| | | | | 1yw | 9 | |
| 2 | T225[b] | Clark 63 | YW | 9YW | 69 | 2.40 |
| | | | | 3Yw | 23 | |
| | | | | 3yW | 15 | |
| | | | | 1yw | 7 | |
| 3 | T225[b] | Clark 63 | YW | 9YW | 66 | 3.40 |
| | | | | 3Yw | 25 | |
| | | | | 3yW | 16 | |
| | | | | 1yw | 4 | |

[a]yellow plant

[b]yellow branch on a variegated plant

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1. Protein, oil and fatty acid composition of certain soybean mutants and mutation-derived lines.

Some mutants and mutation-derived lines of 'S.J.2' and 'Sansai' soybean varieties were obtained after seed irradiation with gamma rays (Smutkupt, 1973; Smutkupt and Gypmantasiri, 1974). Among them, three of S.J.2 lines, three of Sansai lines, including each control and one 'S.J.1' line (see Table 1)

were selected to evaluate for seed yield, protein, oil, fatty acid composition, and other characteristics. Certain plant characteristics of these selected lines are shown in Table 1.

Table 1

Certain characteristics of selected soybean lines

| Original variety | Line number | | Color of | | | Plant height (cm) |
|---|---|---|---|---|---|---|
| | | | Flower | Seed coat | Hilum | |
| S.J.2 | 27-9 | Control | Purple | Yellow | Dark brown | 36 |
| S.J.2 | 41-10 | Mutant* | Purple | Yellow | Dark brown | 19 |
| S.J.2 | 13-8 | Mutant | Purple | Brown | Dark brown | 39 |
| S.J.2 | 30-7 | Mutation-derived | Purple | Yellow | Dark brown | 32 |
| Sansai | 306 | Control | White | Yellow | Brown | 41 |
| Sansai | 18-6 | Mutant | White | Brown | Brown | 48 |
| Sansai | 36-9 | Mutation-derived | White | Yellow | Brown | 42 |
| Sansai | 34-9-1 | Mutation-derived | White | Yellow | Brown | 42 |
| S.J.1 | 56-12 | Mutation-derived | Purple | Yellow | Black | 42 |

*Please see also 'A note on a soybean mutant' in Soybean Genet. Newsl. 1: 39.

The yield trial experiment was carried out in a dry season planting January 1974 at the National Corn and Sorghum Research Center by Chaveevan Chanmesri. It was found that the seed yield of the selected lines in either group of S.J.2 or Sansai was no better than that of the control. The S.J.2 lines matured somewhat earlier than the Sansai lines, which matured in about 100 days. The yield and the plant height of the S.J.2 line No. 41-10, which latter was derived from a yellow seedling mutant, was much reduced.

The seeds from this experiment were used in the chemical analysis. The methods described by the Official and Tentative Methods of the American Oil

Chemists' Society (A.O.C.S., 1971) were used for the determination of moisture, protein, oil, and fatty acid composition. All of the chemical compositions were analyzed by Chaveevan Chanmesri under the supervision of Vimolsri Devapalin at the Oil Seed Laboratory, Department of Agriculture.

The results of the protein content before and after oil extraction, and oil content are shown in Table 2. It was observed that, in general, Sansai lines were higher in protein content than that of S.J.2 lines. In comparison with the control line (No. 27-9), the protein content of S.J.2 mutant line Nos. 41-10 and 13-8 was increased by 1 to 2%. A mutant line No. 18-6 of Sansai was increased in the protein content also by 2%. The highest protein percentage (48%) was observed in Sansai line No. 36-9. The oil content of S.J.2 mutant lines was increased by 1%. In the Sansai variety, the oil content of the mutant line No. 18-6 was decreased less than 1%. The data of protein and oil contents of S.J.2 and Sansai groups showed also the negative correlation of these two characteristics. Certain compositions of selected soybean lines follow:

Table 2

Protein and oil contents (on dry weight basis)

| Line number | % Protein | | % Oil |
|---|---|---|---|
| | Before oil extraction | After oil extraction | |
| 27-9 | 39.78 | 50.58 | 20.66 |
| 41-10 | 40.77 | 50.64 | 21.53 |
| 13-8 | 41.81 | 51.20 | 21.15 |
| 30-7 | 40.17 | 49.01 | 21.40 |
| 306 | 45.60 | 52.46 | 16.75 |
| 18-6 | 47.98 | 53.96 | 15.96 |
| 36-9 | 48.80 | 55.01 | 15.00 |
| 34-9-1 | 47.76 | 54.50 | 15.30 |
| 56-12 | 43.24 | 51.81 | 18.51 |

The data of fatty acid composition in percentages are shown in Table 3. The components of oleic, linoleic and linolenic acids are of interest. In mutants and mutation-derived lines of S.J.2, the oleic acid was reduced, but it was increased in the mutant and mutation-derived lines of Sansai. An increment in linoleic acid as well as linolenic acid of the mutants, and the mutation-derived lines were observed in the S.J.2 variety. In contrast, the reduction of linoleic acid and linolenic acid components was shown in mutant and mutation-derived lines of Sansai variety. It showed the correlation between linoleic acid and linolenic acid components.

Though the data of protein, oil and fatty acid composition were limited to a small number of mutants and mutation-derived lines, it can be seen that the ionizing radiation can create a variability in the quantitative characteristics of soybeans. For particular characters, such as oleic acid, linoleic acid, and linolenic acid components, a difference in varietal response to the ionizing radiation can also be well observed.

Table 3

Percentage of fatty acid composition

| Line number | Palmitic | Stearic | Oleic | Linoleic | Linolenic |
|---|---|---|---|---|---|
| 27-9 | 14.54 | 3.32 | 26.97 | 49.78 | 4.41 |
| 41-10 | 15.52 | 3.70 | 22.12 | 52.87 | 5.53 |
| 13-8 | 13.81 | 3.41 | 25.07 | 52.66 | 4.86 |
| 30-7 | 13.93 | 3.44 | 24.08 | 53.87 | 5.42 |
| 306 | 16.41 | 3.52 | 25.35 | 47.66 | 7.41 |
| 18-6 | 16.58 | 4.19 | 29.23 | 43.07 | 6.92 |
| 36-9 | 16.46 | 4.52 | 27.11 | 44.42 | 7.51 |
| 34-9-1 | 16.67 | 4.26 | 28.69 | 45.46 | 6.76 |
| 56-12 | 14.41 | 3.43 | 36.59 | 43.22 | 4.50 |

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1. European corn borer on soybeans.*

In screening experiments** to determine resistance of several commercial as well as introduced soybean germplasms, it was observed that European corn borer (Ostrinia nubilalis — Hbn), which is a major pest of sweet and field corn, was also infesting soybeans towards the end of the growing season in 1974. Generally the soybeans which were planted late (later than first week of June) were damaged. The larvae were found to bore into the stem, creating tunnels which consequently rendered the stem very brittle. It was not uncommon to observe four to five broken soybean plants as a result of corn borer damage in a 20-foot long row. Previous work (Petty and Apple, 1967) had shown that in early summer the females were observed to show preference in depositing their eggs in relatively more mature corn plants; this preference changed to younger plants in mid-summer; alternative plants (small grains, weeds, flowers) became necessary in the deposition of the eggs by the female moths in the absence of relatively younger corn plants. These observations

*This is a part of a CSRS/USDA funded project.

**These experiments are still in progress on the Experimental Farm at the University of Maryland, Eastern Shore.

tend to confirm current studies being done at UMES. This pest has the potential of causing significant reduction in soybean yield and consequently deserves to be carefully studied with respect to its movement and shift from corn to soybean and its mode of infestation.

Weeds in the vicinity of the soybean field were also examined for European corn borer damage. Pigweed (Amaranthus spp.), Smartweed (Polygonum spp.) and Jimsonweed (Datura stramonium L.) were found to be infested with the larvae of this pest.

Reference

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2. Screening technique for leaf feeding resistance to corn earworm.*

Attempts to determine suitable sources of resistance to a given insect pest or disease has always involved screening large numbers of a given crop. Painter (1951) classified the phenomenon of resistance into three main components, i.e., nonpreference (for oviposition, food or shelter), antibiosis (adverse effect of plant on biology of insect), and tolerance (repair, recovery, or ability to withstand infestation). The search for any one or all of these components of resistance in soybeans (Glycine max (L.) Merrill) to corn earworm (Heliothis zea — Boddie) is a long, time-consuming study in the laboratory, screenhouse, and field. Though each of the above-mentioned components of resistance has some demerits, yet the selections made on the basis of nonpreference and tolerance may prove better in the long run than selections made on the basis of antibiosis. Selections based upon nonpreference and tolerance are less likely to give rise to a new biotype of the insect pest which may survive and reproduce effectively on the new variety having a high level of antibiosis component.

*This is part of a CSRS/USDA funded project.

Tolerance and nonpreference in soybean can be studied in the field and screenhouse, but the limitations imposed by the availability of space and labor discourage the plant breeder from working with a large number of varieties at any given time. Consequently, there is the necessity to develop some suitable laboratory technique which can help eliminate those soybean varieties which are preferred by corn earworm. Barnes and Ratcliffe (1967) developed a leaf disc method of testing alfalfa plants for resistance to feeding by adult alfalfa weevil (Hypera postica – Gyllenhal) and the information obtained through this method was used in establishing a rapid procedure for classifying alfalfa plants for differential feeding by adult weevils.

The object of this study was to develop a laboratory screening technique in leaf feeding experiments for determining resistance to corn earworm involving a number of introductions and available world soybean germplasm. In a previous study (to be published) it was found that PI 227.687, PI 229.358, PI 171.451, and the commercial soybean variety 'Shore' had significantly higher levels of antibiosis for corn earworm when the larvae were raised on the leaves of these PI's/varieties; and D67-3297 had the least level of antibiosis as measured by the gain in larval weight in all the cases. Consequently, PI 227.687 was selected as a resistant variety and D67-3297 was selected as a susceptible variety for this trial. The technique developed at the University of Maryland, Eastern Shore is as follows:

Materials and Methods:

Three discs (2.22 cm diameter) of the resistant leaf (PI 227.687) and three discs of the susceptible leaf (D67-3297) were stapled around a filter paper (11 cm diameter) at equal distances, alternating susceptible and resistant discs. The filter paper was placed in a transparent sandwich box (17.5 cm x 12.5 cm x 6 cm) and kept moist. A corn earworm larva (4th instar) was taken out of the artificial media cup and placed in the center of the filter paper and the box was covered.

Results:

In 24 hours, it was observed that the larva had eaten all the susceptible discs and the remaining three resistant discs were left whole. This experiment was repeated four times, with different combinations of susceptible and resistant discs, with identical results.

It is intended to use this method for screening the world soybean germplasm in order to find soybean varieties with better resistance than present commercial varieties. This method is less time-consuming and many varieties/PI's can be tested in a relatively short time.

References

Barnes, D. K. and R. H. Ratcliffe. 1967. Leaf disc method of testing alfalfa plants for resistance to feeding by adult alfalfa weevils. Jour. Econ. Ent. 60(6): 1561-1565.

Painter, R. H. 1951. Insect resistance in crop plants. University Press of Kansas, Lawrence and London. pp. 25-28.

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1. Some inter-relationships between days to first bloom and days to maturity.

Extending number of days to first bloom is a positive means for increasing total growth for short-season, determinate growth habit soybeans. Increasing number of days to first bloom is also effective in increasing the height of lowest pods.

In an attempt to develop productive strains of Group IV maturity with good quality seed, we used PI 171.450 as a parent. PI 171.450 is described as a "summer type" in Japan where it is grown at approximately 33°30' latitude. It has a determinate growth type and flowers late for its maturity (Group III). 'Hill' of early Group V maturity also flowers late for its maturity. Previously, we had converted 'Lee', an adapted Group VI variety, to Group IV maturity, using a backcrossing program with 'Hawkeye' as the nonrecurrent parent. All determinate Group IV plants were extremely short with pods at ground level. We evaluated advanced $F_5$ lines selected from Hill(2) x PI 171.450 in a replicated trial at Stoneville on Sharkey clay. Two indeterminate growth habit varieties, 'Custer' and 'Kent', were grown as checks.

Yield of Kent was less than 50% of that for Custer, because of injury from phytophthora rot and bacterial pustule. Consequently, comparisons were made only with Custer. Performance data for selected lines from a planting made May 14, 1969 are reported:

| Strain | Date first bloom | Days to first bloom | Date mature | Days first flowers to maturity | Total days to maturity | kg/ha |
|---|---|---|---|---|---|---|
| Custer | 6-12 | 29 | 9-11 | 99 | 128 | 2657 |
| D67-2896 | 7-6 | 53 | 9-14 | 70 | 131 | 2946 |
| D67-2908 | 6-25 | 42 | 9-1 | 67 | 117 | 2354 |
| D67-2984 | 6-30 | 47 | 9-1 | 62 | 117 | 2583 |
| D67-3297 | 7-2 | 49 | 9-11 | 79 | 128 | 2610 |

D67-2896, which yielded nearly 300 kg/ha more than Custer, flowered 24 days later but matured only 3 days later. Thus, the fruiting period was reduced by 29 days. D67-2908 and D67-2984 matured 10 days earlier than Custer. D67-2984 had a 5-day shorter fruiting period than D67-2908 but produced a higher seed yield. Corn breeders have pointed out that attempts to shorten fruiting period in corn have resulted in lower seed yields. However, it appears that the short fruiting period for the late-flowering soybean strains is as long or longer than for corn.

In addition to yielding well, the late-flowering strains were superior to Custer and Kent in seed holding and seed quality. These results illustrate the possibilities for modifying days to first bloom without much change in days to maturity.

When planted under 12 hr 30 min photoperiod conditions, most varieties adapted for production in the southern U.S. will flower in 28-32 days after emergence. Under these conditions, Hill flowers 38-42 days after emergence. 'Hardee', of late Group VII maturity, also flowers in 38-42 days. Several strains of Group VIII maturity, which mature earlier than Hardee when grown in the field at Stoneville, require 50-58 days to reach early bloom stage when planted under 12 hr 30 min conditions. It is anticipated that these strains will be useful as parent material for developing determinate growth type

varieties for short-day regions which make adequate growth but mature in 125-135 days.

Days to first bloom can also influence lodging. Strains of Group V maturity selected at Stoneville (latitude 33°20') tend to lodge when grown in the production area of eastern Virginia and Maryland (latitude 38°). Strains selected for lodging resistance at Warsaw, Virginia, are short when grown at Stoneville. Among strains of similar maturity, strains selected at Warsaw flower 7 to 10 days earlier at Stoneville than strains selected at Stoneville.

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1. An allelic series affecting stem length.

'Chief', a very tall Maturity Group IV variety, was used as a donor parent in backcrossing to 'Clark' to transfer Np (a gene for high phosphorus tolerance). In the field in 1963, I grew progenies from 40 selected Np $F_2$ plants from Clark $BC_5$ and was surprised to see 2 of the progenies uniformly very tall and 3 of them segregating approximately 1/4 tall plants. The Np gene appears to have no effect on field-grown plants in normal soils. In the $F_3$ progenies grown in 1964, from 121 $F_2$ plants of the 3 segregating rows, there were 31 uniformly tall rows, 62 segregating rows, and 28 rows similar to Clark, a good fit to a 1:2:1 ratio (expected 30:61:30). Within each segregating row there again appeared to be about 1/4 tall plants but accurate classification could not be made because of normal plant-to-plant variation in growth.

Forty plants from Clark-like rows averaged 38 inches in height (33 to 42 range) and 23 nodes. Forty plants from tall rows averaged 47 inches (43 to 52 inch range) and 23 nodes. In a 1968 test, Clark plants averaged 46 inches and 22 nodes on the main stem; the tall isoline averaged 54 inches and 23 nodes.

Therefore there seems to be a single recessive gene in Chief which, in a Clark background, increases mainstem length chiefly by lengthening the internodes, since there is little effect on the number of nodes.

'Higan', a short, determinate Maturity Group IV variety (introduced from Japan in 1929 as 'Higan Mame'), was being used as a donor parent of appressed and semisparse pubescence in backcrossing to Clark and 'Harosoy'. In 1964, in Harosoy $BC_3$ and $BC_4$ $F_3$ lines (all $\underline{Dt_1}\underline{Dt_1}$), I noted that there was segregation for short height and that it was not related to stunting because of pubescence type. In the $F_3$ progenies of 103 $F_2$ $BC_3$ plants, there were 31 all short progenies:50 segregating:22 uniformly Harosoy height, a good fit to 1:2:1 (expected 26:51:26, $X^2P$ = .5). Individual plant counts in 11 segregating rows totalled 367 short plants and 109 of Harosoy height, a good 3:1 fit (expected 357:119, $X^2P$ = .3). In $BC_4$ in 1964 and 1965, there were 42 short, 76 segregating, and 38 progenies of Harosoy height (expected 39:78:39, $X^2P$ = .9).

Twenty plants measured in the $BC_4$ Harosoy-like progenies averaged 36 inches tall with 18 mainstem nodes; 20 from short progenies averaged 28 inches and 16 nodes. In 1965, among a large $BC_5$ Clark population, I found one line segregating for apparently the same short stem trait. In crosses to Clark, it segregated in the same way as did the trait in Harosoy. In crosses between Harosoy-short and Clark-short isolines, all progenies were short in the $F_1$ and $F_2$.

Therefore, I concluded that there is a single dominant gene in Higan which in a Harosoy or Clark background reduced height by shortening internode length and reducing node numbers slightly.

In 1970, the $F_2$ of the cross combining the short and tall Clark isolines (L67-592 X L64-1731) was grown and 65 plants were measured and harvested. The 1971 $F_3$ progeny test resulted as shown on the next page. Although the heterozygote appears to be Clark-like in height, there were no uniformly Clark-like progenies. I concluded that the genes were multiple alleles and symbolized them as indicated in the tables. (Woodworth used the symbols $\underline{S}$ $\underline{s}$ for short and tall stem in a paper in 1923 but immediately discarded the material so it cannot be proved that these are the same.)

| $F_3$ phenotype | $F_2$ plant height | | $F_3$ progenies | | Proposed genotype |
|---|---|---|---|---|---|
| | Ave. | Range | Observed | Expected (1:2:1) | |
| All short | 37.1 | 34-41 | 11 | 16.2 | $\underline{SS}$ |
| Segregating | 41.5 | 38-45 | 36 | 32.5 | $\underline{Ss}^t$ |
| All tall | 53.7 | 48-60 | 18 | 16.2 | $\underline{s}^t\underline{s}^t$ |
| Clark check | 41.8 | 40-46 | | | $\underline{ss}$ |

$X^2P = .3$

In 1968, we grew and measured the isolines as follows:

| | Proposed genotypes | $BC_5$ line | Height | No. of nodes | Average internode |
|---|---|---|---|---|---|
| Harosoy | $\underline{s}$ | | 37 inches | 20 | 1.9 inches |
| Harosoy-short | $\underline{S}$ | L67-234 | 27 | 17 | 1.6 |
| Clark | $\underline{s}$ | | 46 | 22 | 2.1 |
| Clark-short | $\underline{S}$ | L67-592 | 37 | 21 | 1.8 |
| Clark-tall | $\underline{s}^t$ | L64-1731 | 54 | 23 | 2.3 |

The shorter allele appeared to be dominant in each combination, but the average measurements of $\underline{Ss}^t$ plants given above show them to be about 4 inches taller than $\underline{SS}$ plants. Likewise, average measurements of $\underline{Ss}$ plants were 2 inches taller than $\underline{SS}$ plants (in 1972 at Urbana). I have no comparable measurements of $\underline{ss}^t$ plants but suspect that they would be slightly taller than $\underline{ss}$ plants. The genotypes in order of ascending height would then be:

$$\underline{SS} - \underline{Ss} - \underline{Ss}^t - \underline{ss} - \underline{ss}^t - \underline{s}^t\underline{s}^t$$

R. L. Bernard — USDA

2. The inheritance of near-gray pubescence color.

There are two common pubescence color types in the soybean, brown (usually called tawny), and gray, controlled by the gene pair T-t with tawny being dominant. The T-t gene pair also affects seed pigments with T producing black or brown in the seed or hilum and t producing imperfect black or buff.

However, there are a few black or brown-seeded varieties that have an intermediate pubescence color ranging from light tawny to near-gray. Previous genetic studies of this pubescence color (Probst, 1950; Williams, 1952) were inconclusive, perhaps chiefly because they recognized only two colors, tawny and gray, and intermediate colors were inconsistently classified as either tawny or gray. In crosses of light tawny or near-gray varieties by the common varieties with gray pubescence (t), normal tawny pubescent segregates appear and seed coat segregation occurs exactly as in a T x t cross. Therefore, we may safely assume that these light tawny and near-gray types carry the T gene, and the reduction in brown pigment in pubescence is due to one or more genetic modifiers. The following presents evidence for one major gene pair controlling normal dark tawny versus light tawny, here designated Td-td.

'Grant', a variety with light tawny pubescence, was crossed with 'Clark', which has normal (dark) tawny pubescence. The $F_2$ segregated 3 tawny: 1 light tawny (148:49, expected 147.8:49.2). In this cross I did not discriminate between near-gray and light tawny. All light tawny $F_2$ plants bred true, 10 tawny plants bred true, and 23 segregated 3 tawny:1 light tawny in the $F_3$ (436:152, expected 441:147, $X^2P = .6$).

The cross of Harosoy-i (t, gray pubescence) x Grant gave a tawny $F_1$. The $F_2$ segregated 73 tawny:33 light tawny:36 gray, close to a 9:3:4 ratio (expected 79:27:36, $X^2P = .4$). All gray $F_2$ plants bred true in the $F_3$. Only 3 light tawny plants were tested, and 2 segregated 3 light tawny to 1 gray and 1 bred true. Of the tawny $F_2$ plants, 2 bred true, 15 segregated 3 tawny : 1 gray, 8 segregated 3 tawny : 1 light tawny, and 9 segregated 9:3:4 again. $F_3$ families were too small to test ratios accurately, but all expected combinations were present. Since Clark x Harosoy segregated in the normal 3 tawny : 1 gray ratio, the following genotypes were apparent from the above two crosses:

| | | |
|---|---|---|
| Grant | Light tawny | T td |
| Clark | Tawny | T Td |
| Harosoy-i | Gray | t Td |

Grant is a selection from Lincoln (T, tawny pubescence) x 'Seneca' (t, gray pubescence), and so I suspected that Seneca was t td. The $F_2$ of Seneca x Clark segregated 9:3:4 (181:72:98, expected 197:72:88, $X^2P = .4$) just like Harosoy x Grant, which confirmed the hypothesis.

In Grant x Clark, all hilum pigment was black. In Harosoy-i x Grant, all tawny and light tawny plants had black or brown hilums and all gray plants had imperfect black or buff hilums. The genes R-r (black versus brown) and $i^i$-i (dark hilum versus self dark seed) showed no evidence of interaction or close linkage with Td-td. Therefore it seems that Td-td has no effect on hilum or seed coat pigments but affects only pubescence color.

Grant was crossed with other light tawny and near-gray varieties, 'Cloud', 'Kingwa', 'Korean', 'Sooty', T109, and T240, and no tawny or true gray plants appeared in the $F_1$ or $F_2$. I concluded that all of them had the gene td (as well as T), but I have not been able to ascertain the genetic basis for the difference between the light tawny varieties, Grant, Korean, and T240, and the near-gray ones, Cloud, Kingwa, Sooty, and T109. $BC_5$ isolines of Clark using Grant, Seneca, Sooty, and T240 as donors all have a similar near-gray appearance regardless of the source of td.

In crosses of some of the near-gray varieties with Clark, there was a wide range of pubescence color in the $F_2$, with classification difficult or impossible. The development of tawniness is affected by maturity, amount of pubescence, etc. and when these factors were segregating, accurate classifications were not possible. However, after a few backcrosses to Clark, the monogenic control of near-gray pubescence became apparent.

While observing some of the Clark backcross populations (using Sooty and T240 as donors), I noted that the $F_1$ and many of the $F_2$ plants were a medium tawny color, somewhat lighter than Clark (and slightly darker than the light tawny of Grant). I classified 353 plants and their progenies in segregating $BC_1$ to $BC_4$ and found 84 all-tawny progenies : 192 segregating : 77 all near-gray (which fits a 1:2:1 ratio with a $X^2P = .2$). The parent plants had been classified with better than 90% accuracy; virtually all

near-gray plants bred true (in one cross, 3 plants were misclassified) and most of the dark tawny and medium tawny plants bred true and segregated, respectively. Probably with experience, this discrimination could be made completely accurate.

The genotypes and corresponding phenotypes are summarized below.

| | | |
|---|---|---|
| T T Td Td | (Dark) tawny | (Clark) |
| T T Td td | Medium tawny | |
| T T td td | Light tawny or near-gray | (Grant, Sooty, etc.) |
| t t Td Td | Gray | (Harosoy, etc.) |
| t t td td | Gray | (Seneca) |

References

Probst, A. H. 1950. The inheritance of leaf abscission and other characters in soybeans. Agron. J. 42: 35-45.

Williams, L. F. 1952. The inheritance of certain black and brown pigments in the soybean. Genetics 37: 208-215.

R. L. Bernard — USDA

3. The inheritance of semi-sparse pubescence.

Sparse pubescence from T240, controlled by a single dominant gene, Ps, was reported by Bernard and Singh (1969). In backcrosses of 'Higan' to 'Clark' and 'Harosoy' to study appressed pubescence, a semi-sparse pubescence type was observed segregating apparently independently of the appressed pubescence. In backcrosses to both Harosoy and Clark it behaved as a single dominant gene. $F_1$ plants of $BC_3$ to $BC_5$ Clark (crossed with semi-sparse $F_1$'s of the previous backcross) totalled 86 semi-sparse and 85 all normal pubescence, a good fit to 1:1. Thirty-three semi-sparse $F_1$ $BC_4$ plants produced 3 semi-sparse : 1 normal in the $F_2$ (total 232:96, expected 246:82).

In an $F_2$ of $BC_5$ Clark in 1963, we classified $F_2$ plants into 3 pubescence levels and progeny tested the $F_3$ in the sand bench in the greenhouse. All normal plants bred true. The semi-sparse $F_2$ plants were divided into two levels of sparseness and, for the most part (over 80%), the less sparse group segregated (273:98, $X^2P = .5$) and the more sparse ones bred true, indicating that dominance is not complete.

I selected true-breeding semi-sparse isolines of Harosoy and Clark $BC_5$ and counted pubescence on a 1 mm length of the 5th internode on several plants. Hair counts averaged for Harosoy, 58; Harosoy — Ps (sparse), 20; Harosoy — semi-sparse, 29; Clark, 78; Clark — Ps, 21; and Clark — semi-sparse, 52. In classifying field plants, I found that the stems of semi-sparse were obviously more pubescent than those of sparse plants, but to distinguish normal and semi-sparse I often used the pulvinus which is densely hairy on normal plants and very slightly hairy on semi-sparse ones.

Using Clark $BC_5$ isolines, I crossed semi-sparse with glabrous ($P_1$), curly (pc), dense (Pd), and sparse (Ps), and observed the $F_2$. All combinations segregated as expected for independent genes, except for semi-sparse x sparse, which segregated 3 sparse : 1 semi-sparse : 0 normal (62:24, expected 64.5:21.5). In the $F_3$, the progeny were as follows: all 17 semi-sparse bred true, 17 sparse bred true, and 29 sparse segregated 3 sparse : 1 semi-sparse, (expected 15.8:15.8:31.5). Among the several hundred $F_3$ plants observed, there were no normal pubescent plants. Thus I concluded that semi-sparse was controlled by a third allele at the Ps-ps locus and symbolize it as $Ps^s$.

Reference

Bernard, R. L. and B. B. Singh. 1969. Inheritance of pubescence type in soybeans: glabrous, curly, dense, sparse, and puberulent. Crop. Sci. 9: 192-197.

R. L. Bernard — USDA

4. The inheritance of appressed pubescence.

A large number of soybean varieties (more than 100) in our germplasm collection have hairs that are appressed to the upper leaf surface. They appear normally erect elsewhere on the plant. This is especially common in Maturity Group IV, and among varieties from Japan and Korea. It is common but not universal in wild soybean (G. soja). In the north central U.S., appressed pubescent varieties are often heavily fed on and stunted by the potato leafhopper (Empoasca fabae), but in Asia they may have some resistance to pod borer.

Appressed pubescence was one of the first pubescence types to be

described (Woodhouse and Taylor, 1913). Karasawa (1936) crossed an erect pubescent soybean x an appressed wild soybean and proposed a single dominant gene for appressed pubescence, although his $F_2$ data fit a digenic ratio (13:3) closer than a 3:1. Ting (1946) also crossed wild x cultivated soybeans and reported that his results were similar to Karasawa's. However, in this case the wild strain (PI 163.453) had erect pubescence and the cultivated one had appressed pubescence. No data were presented but the symbols A-a were used in a summary table.

For this study I used the appressed variety 'Higan' (introduced as 'Higan Mame' from Tokyo in 1929) and the erect varieties 'Clark' and 'Harosoy'. In crosses of erect x appressed, there were many plants intermediate between the parents in pubescence type, and because there was wide segregation for maturity, plant type, and density of pubescence, discrete classes of pubescence type were not discernible. Therefore, I transferred the appressed trait to Clark and Harosoy by backcrossing, and obtained true-breeding $BC_5$ lines that appeared fully as appressed as Higan. During the backcrossing, the frequency of families with appressed segregates indicated that Clark and Harosoy differed from Higan by two genes. In the $F_2$, from selected $F_1$ plants of Harosoy$^6$ x Higan, and of Clark$^6$ x Higan, the three phenotypes — erect, semi-appressed, and appressed — occurred in a 4:11:1 ratio. In the $F_3$, plants were subdivided into additional phenotypic classes. Although individual plant classification was not always certain, the progeny rows fell into distinct classes as outlined in Table 1.

It is somewhat arbitrary which way the gene symbols are assigned, but the heterozygotes appeared closer to the less-appressed homozygote and so I let $\underline{pa_1}\,\underline{pa_2}$ represent the appressed genotype. Probably Karasawa (1936) and Ting (1946) were dealing with segregation for one or both of these gene pairs.

Probably all 7 genotypes in Table 1 have slightly different phenotypes but I was able to discriminate only the 4 or 5 specified. The true-breeding semi-appressed type ($\underline{pa_1}\,\underline{Pa_2}$) perhaps explains the phenotype of varieties such as 'Scott', 'Custer', and 'Oksoy'. The true-breeding recombination $\underline{Pa_1}\,\underline{pa_2}$ appears to be erect and indistinguishable from Clark or Harosoy, which are $\underline{Pa_1}\,\underline{Pa_2}$.

As further proof of 2-gene control, a $\underline{Pa_1}\,\underline{Pa_1}\,\underline{pa_2}\,\underline{pa_2}$ line was obtained

Table 1

Phenotypes and genotypes in a cross of Harosoy or Clark (erect pubescence) x Higan (appressed)

| $F_2$ phenotype | $F_2$ genotype | Observed $F_3$ segregation | Number of families | | |
|---|---|---|---|---|---|
| | | | Observed | | |
| | | | Harosoy | Clark | Expected |
| Erect | $\underline{Pa_1}\underline{Pa_1}$ — — | All erect | 23 | 26 | 22 |
| Near-erect | $\underline{Pa_1}\underline{pa_1}\underline{Pa_2}\underline{Pa_2}$ | 1E:2NE:1SA | 14 | 11 | 11 |
| Near-erect | $\underline{Pa_1}\underline{pa_1}\underline{Pa_2}\underline{pa_2}$ | 4E:6NE:5SA+NA*:1A | 23 | 19 | 22 |
| Semi-appressed | $\underline{Pa_1}\underline{pa_1}\underline{pa_2}\underline{pa_2}$ | 1E:2SA:1A | 6 | 11 | 11 |
| Semi-appressed | $\underline{pa_1}\underline{pa_1}\underline{Pa_2}\underline{Pa_2}$ | All semi-appressed | 5 | 6 | 5.5 |
| Near-appressed | $\underline{pa_1}\underline{pa_1}\underline{Pa_2}\underline{pa_2}$ | 3SA+NA*:1A | 11 | 13 | 11 |
| Appressed | $\underline{pa_1}\underline{pa_1}\underline{pa_2}\underline{pa_2}$ | All appressed | 6 | 2 | 5.5 |
| | | | 88 | 88 | 88 |
| | | $X^2P$ = | .8 | .7 | |

*SA and NA were not discriminated.

by selecting an erect plant from a family that was segregating 1 erect : 2 semi-appressed : 1 appressed. When this was crossed with a semi-appressed line ($\underline{pa_1}\underline{pa_1}\underline{Pa_2}\underline{Pa_2}$) there were fully appressed segregates observed in the $F_2$ as would be expected from the above genetic explanation. This was observed in both Clark and Harosoy backgrounds.

Using Clark isolines, I have obtained recombinants of appressed ($\underline{pa_1}\underline{pa_2}$) with several other pubescence types — glabrous ($\underline{P_1}$), curly ($\underline{pc}$), dense ($\underline{Pd}$), irregular ($\underline{pi}$), and sparse ($\underline{Ps}$) — which demonstrate that $\underline{pa_1}$ and $\underline{pa_2}$ are not allelic to any of these.

References

Karasawa, K. 1936. Crossing experiments with Glycine soja and G. ussuriensis. Jap. J. Bot. 8: 113-118.

Ting, C. L. 1946. Genetic studies on the wild and cultivated soybeans. J. Amer. Soc. Agron. 38: 381-393.

Woodhouse, E. J. and C. S. Taylor. 1913. The varieties of soybeans found in Bengal, Bihar, and Orissa, and their commercial possibilities. India Dep. Agr. Mem., Bot. Ser. 5: 103-175.

R. L. Bernard — USDA

5. Inheritance of the Eldorado male-sterile trait.

A partially male-sterile strain (Stewart and Wentz, 1926; Bernard and Jaycox, 1969) and a completely male-sterile strain (Brim and Young, 1971), controlled by single recessive genes $\underline{p}_2$ and $\underline{ms}_1$ respectively, have been reported in soybeans. We now have evidence for a second completely male-sterile type controlled by a single recessive gene at a different locus from $\underline{ms}_1$.

In 1971, in an $F_3$ breeding population at Eldorado, Illinois, we observed at maturity about 20 poorly-podded plants out of a total of about 500. These plants had a high number of seeds per pod in contrast to the typical semi-sterile, which has mostly one-seeded pods. We therefore suspected male sterility and harvested several plants for further study. The parentage of this $F_3$ population was SL11 x L66L-177. SL11 is a backcross-derived isoline of 'Wayne' with brown hilum (r from T145), and resistance to downy mildew (Rpm from 'Kanrich') and phytophthora rot (Rps from 'Clark 63'). L66L-177 is a selection from Wayne x L57-9819 (Hawkeye x Lee).

Since sterility has not been observed in either parent line, this trait presumably arose by mutation. The $F_3$ population was produced from the $F_2$ by single-pod descent, and, because several sterile plants were found in the $F_3$, the mutation must have occurred earlier, probably in one of the $F_1$ plants or perhaps in one of the parent plants. Ten plants were grown in the greenhouse in the winter of 1971-72 from sterile plant L71L-06-4 and all were fertile. In 1972, each of the 10 progenies segregated 3 fertile : 1 sterile (260:92, expected 264:88). The sterile plants had much-reduced anthers, and nothing resembling pollen was produced (in contrast to the North Carolina male-sterile ($\underline{ms}_1$) which produces near normal anthers). At maturity the sterile plants averaged 12.7 seeds per plant or about 13% as many as the fertile sibs. Pollinations were made on steriles with a success rate nearly as high as on normal plants. In four years of hand-pollinations where fertile plants averaged 51% pod set, the Eldorado male-sterile averaged 42%, in contrast to $\underline{ms}_1$ in a related genetic background, which averaged 16%. Therefore, we concluded that female fertility is almost normal for the Eldorado male-sterile. Heterozygous progeny of L71L-06-4 has been added to the Genetic Type Collection as T259H.

In 1973, we grew the progeny of 32 fertile plants from one of the segregating lines and found that 6 bred true and 26 segregated 3:1 (532:184, expected 537:179). Data from backcross populations (Table 1) also substantiated control by a single recessive gene. The tendency toward an excess of steriles in 'Wells' backcrosses needs further investigation.

In order to test the relationship to $\underline{ms}_1$, we made crosses using male-steriles as the female and heterozygotes as the male parent as shown in Table 2. All $F_1$ plants were fertile. In the $F_2$, as would be expected if the North Carolina and Eldorado genes were at separate and unlinked loci, half of the families segregated 3:1 and half segregated 9:7. Except for the two indicated in the table, all families differed at the 1% probability level from the alternative ratio (by chi-square test).

We propose the symbol $\underline{ms}_2$ for this male sterility and have a few seeds of $BC_5$ 'Williams' carrying $\underline{ms}_2$ available for distribution to breeders and other researchers.

Table 1

Evidence for segregation of $\underline{ms}_2$ in backcross populations

| | No. of $F_2$ lines | | Progeny of segregating lines | | |
|---|---|---|---|---|---|
| | All fertile | Segregating | Fertile | Sterile | $X^2P$ (3:1) |
| Williams $BC_1$ | 13 | 11 | 241 | 85 | .7 |
| Williams $BC_2$ | 2 | 6 | 243 | 78 | .8 |
| Williams $BC_3$ | 4 | 4 | 60 | 20 | 1.0 |
| Williams $BC_4$ | 7 | 5 | 161 | 58 | .6 |
| Beeson $BC_2$ | 3 | 5 | 108 | 30 | .3 |
| Beeson $BC_3$ | 4 | 1 | 19 | 5 | .6 |
| Wells $BC_1$ | 2 | 3 | 52 | 22 | .3 |
| Wells $BC_2$ | 7 | 8 | 219 | 94 | .04 |
| Wells $BC_3$ | 2 | 3 | 42 | 28 | .004 |
| Total | 44 | 46 | 1145 | 420 | .09 |
| Expected | 45 | 45 | 1174 | 391 | |

Table 2

$F_2$ ratios from crosses of Eldorado and North Carolina male-steriles

| Parentage* | No. of families with $F_2$ ratios 3:1 | 9:7 |
|---|---|---|
| T259 x ($F_1$ T260 x L6[4]) | 7** | 9 |
| ($F_2$ Williams[4] x T259H) x ($F_1$ T260 x L6[5]) | 6 | 2 |
| ($F_2$ T260 x L6[4]) x ($F_1$ T259 x L6) | 2** | 4 |
| Total | 15 | 15 |
| Total fertile plants | 897 | 733 |
| Total sterile plants | 300 | 596 |
| $X^2P$ (3:1) | .77 | <.01 |
| $X^2P$ (9:7) | <.01 | .42 |

*Female parents were male-sterile plants; male parents were known heterozygotes. L6 is a line almost identical to Clark 63. T259 is the original Eldorado male-sterile line. T260 is the North Carolina male-sterile line received from C. A. Brim.

**One of these families did not differ significantly from a 9:7 ratio.

References

Bernard, R. L. and E. R. Jaycox. 1969. A gene for increased natural crossing in soybeans. Agronomy Abstracts, 1969. p. 3.

Brim, C. A. and M. F. Young. 1971. Inheritance of a male-sterile character in soybeans. Crop Sci. 11: 564-566.

Stewart, R. L. and J. B. Wentz. 1926. A recessive glabrous character in soybeans. J. Amer. Soc. Agron. 18: 997-1009.

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6. Inheritance of a tan saddle mutant.

A dark saddle pattern occurs in a few native varieties of soybeans from eastern Asia and has arisen as a mutant in several U.S. varieties.

Its presence is controlled by gene $\underline{k}$ (now $\underline{k_1}$) ('Kura', 'Agate', T153 mutant in 'Lincoln') or by $\underline{i}^k$, an allele of the $\underline{I}$-$\underline{i}^i$-$\underline{i}$ locus ('Black Eyebrow'). The color of the saddle, black, brown, imperfect black, or buff, is controlled by the same genes that control hilum color, $\underline{O}$-$\underline{R}$-$\underline{T}$-$\underline{W}$ (see Bernard and Weiss, 1973, for review).

A different kind of saddle pattern has arisen as a mutant at least five times in material that we have observed. This pattern covers the same area of the seed but is always tan and is independent of the effects of hilum color genes. The seed coat beyond the tan saddle pattern is usually slightly darker than in normal yellow seeds.

Two mutants were found at Columbia, Missouri, by L. F. Williams: T261 in 'Ottawa Mandarin' about 1955, and L67-3483 in irradiated 'Clark' in 1956 (tan saddle with a black hilum). The other three were found at Urbana by R. L. Bernard: L58-360 in PI 54.809 in 1956 in 1952-produced seeds, T239 in 'Harosoy' in 1961, and L67-4323 in Harosoy-L2 (a pure line of Harosoy) in 1965.

We crossed T261 with L58-360, and only tan saddle progeny occurred in the $F_1$ and $F_2$ which indicated that the mutated genes were the same in both. R. G. Palmer (personal communication) has crossed T261 with T253 and only tan saddle progeny occurred in the $F_1$ and $F_2$, which indicated that the mutated genes were also the same in both. (In 1963, a chlorophyll-deficient mutant was found in T239 and this tan saddle chlorophyll-deficient mutant is T253.)

The $F_1$ of T261 x Harosoy was yellow-seeded, and the $F_2$ segregated 3 yellow : 1 tan saddle (189:53, expected 182:60, $X^2P = .3$). Fifty-two yellow-seeded $F_2$ plants produced 21 true-breeding $F_3$ lines and 31 that segregated 3 yellow-seeded : 1 tan saddle (410:125, expected 401:134, $X^2P = .4$). Twelve $F_2$ plants with tan saddle gave only tan saddle progeny. An occasional obvious mixture or outcrossed plant was rogued. The cross of L65-461 (a yellow-seeded $BC_5$ isoline from Harosoy$^6$ x T176) x T261 also segregated 3 yellow-seeded : 1 tan saddle in the $F_2$ (80:26, expected 80:26).

We crossed Clark-$\underline{k_1}$ (a mutant of Clark with black saddle) x T261. The $F_1$ had no saddle and the $F_2$ segregated 124 yellow seed coat : 46 tan saddle : 53 $\underline{k_1}$-type saddle. This was a close fit to a 9:3:4 (expected 125:42:47, $X^2P = .6$). We concluded that a single recessive gene, which we designated

Table 1

| | $\underline{K_1}\underline{K_2}$ | $\underline{k_1}\underline{K_2}$ | $\underline{K_1}\underline{k_2}$ | $\underline{k_1}\underline{k_2}$ |
|---|---|---|---|---|
| $\underline{i^i RT}$ | Black hilum | Black saddle & hilum | Black hilum & tan saddle | Black & tan saddle |
| $\underline{i^i Rt}$ | Imperfect black hilum | Imperfect black saddle & hilum | (not observed) | Imperfect black & tan saddle |
| $\underline{i^i rT}$ | Brown hilum | Brown saddle & hilum | Brown hilum & tan saddle | Brown & tan saddle |
| $\underline{i^i rt}$ | Buff hilum | (not observed) | (not observed) | (not observed) |
| $\underline{IRT}$ | Gray hilum | Near self black | Gray hilum & tan saddle | Near self black |
| $\underline{IRt}$ | Gray hilum | Near self imperfect black | Gray hilum & tan saddle | Near self imperfect black |
| $\underline{IrT}$ | Yellow hilum | Near self brown | Tan hilum & saddle | Near self brown |
| $\underline{Irt}$ | Yellow hilum | Near self buff | Tan hilum & saddle | Near self buff |

$k_2$, not allelic or linked to $k_1$, controlled the tan saddle mutant T261 from Ottawa Mandarin and also the ones from PI 54.809, T239, and T253; and, because of their similar appearance, probably also the tan saddle mutants from Clark and Harosoy-L2.

In the cross of Clark-$k_1$ x T261, there were several contrasting seed-pigment genes. The parental genotypes are:

Clark-$k_1$ $i^i k_1 K_2 R T W_1$

T261 $I\ K_1 k_2 r t W_1$

Because of partial or complete epistasis and incomplete dominance in some combinations, an accurate complete classification was not possible. However, the following phenotypes were observed among the 244 $F_2$ plants ($K_1$ = $K_1$_, $k_1$ = $k_1 k_1$, etc.) (see Table 1).

The absence of certain phenotypes was due either to their not being present in this small population or to their not being distinguishable from other phenotypes. Tan saddle was generally hypostatic to near self black or brown ($k_1 I$) but usually identifiable in combination with black or brown saddle ($k_1 i^i$).

In summary, there appeared to be no interaction effects of tan saddle with the other seed pigment genes except as near-self or dark saddle obscured the tan saddle or as tan saddle obscured the light hilum colors such as yellow or buff.

Reference

Bernard, R. L. and M. G. Weiss. 1973. Qualitative Genetics. pp. 117-153. In B. E. Caldwell (ed.) Soybeans: Improvement, Production, and Uses. Amer. Soc. Agron., Madison, Wis.

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7. Inheritance of wavy leaf.

Plants with wavy leaves from crosses between non-wavy parents were observed at Urbana prior to 1950 by L. F. Williams. He indicated in an unpublished report that he had observed them in crosses involving 'Dunfield' or 'Chief' as one parent and PI 70.478, PI 79.885, T117, or 'Manchuria 13177' as

the other. T176, the wavy-leafed strain used in the current study, was presumably selected from one of these crosses. The waviness is mainly in the margin of the leaflets. A few commercial varieties such as 'Ottawa Mandarin' and 'Lindarin' show a very slight tendency toward waviness but this is much less marked than the wavy phenotype reported here.

Inheritance studies at Urbana from 1972 to 1974 indicated that wavy leaf was controlled by two recessive genes (here designated $\underline{lw_1}$ and $\underline{lw_2}$), with both necessary for its expression. Moreover, in the presence of $\underline{T}$ (tawny pubescence), wavy leaf was not expressed. T176 (wavy) was crossed with T205, a wavy selection from Dunfield x Manchuria 13177, and all progenies were wavy.

A cross of T176 (wavy) x 'Harosoy' gave evidence for one of these gene pairs. The $F_1$ was non-wavy and the $F_2$ segregated 3:1 (196 non-wavy : 63 wavy). In $F_3$ progeny tests, 20 non-wavy $F_2$ plants bred true, 32 segregated 3:1 (including one $F_2$ questionably classified wavy), and 21 $F_2$ wavy plants bred true, a reasonable fit to 1:2:1.

The cross of T176 x Clark (tawny pubescent) also gave evidence for the same gene but all tawny pubescent segregates were non-wavy. The $F_1$ was non-wavy and the $F_2$ segregated 12:3:1 (246 tawny and non-wavy : 55 gray and non-wavy : 19 gray and wavy). The $F_3$ progeny tests were as expected, with a few lines segregating only tawny non-wavy and gray wavy plants.

Since wavy plants do not occur in crosses of Clark with Harosoy, the gene evidenced above must be the same non-wavy gene in both crosses, and it is here designated $\underline{Lw_1}$ with T176 having $\underline{lw_1}$. We backcrossed and selected $BC_5$ lines as follows:

| Phenotype | Designation | Parentage |
|---|---|---|
| Wavy | Harosoy-$\underline{lw_1}$ | Harosoy$^6$ x T176 |
| Wavy | Clark-$\underline{lw_1}$ $\underline{t}$ | Clark$^6$ x T176 |
| Non-wavy | Clark-$\underline{lw_1}$ | Clark$^6$ x T176 |

A cross of Clark-$\underline{t}$ x T117 gave evidence for a second gene pair. (Clark-$\underline{t}$ is a gray pubescent $BC_5$ isoline from Clark$^6$ x Higan). Both parents and the $F_1$ were normal, and the $F_2$ segregated 15:1 (277 non-wavy : 24 wavy; expected 282:19). Thus, Clark must carry at a second locus an allele for waviness, here designated $\underline{lw_2}$, which combines with $\underline{lw_1}$ from T117 to produce the wavy phenotype.

Further evidence for this second gene came from crosses of wavy x T117 where only the second locus was segregating. The $F_1$'s of T176 x T117 and Clark-$\underline{lw_1 t}$ x T117 were non-wavy and the $F_2$'s segregated 3:1 (156 non-wavy : 44 wavy, and 135:46, respectively). In an $F_3$ progeny test of T176 x T117, 26 lines were all non-wavy, 52 segregated, and 22 were all wavy (1:2:1).

Further evidence for the epistatic effect of $\underline{T}$ on waviness came from $F_2$ populations of Clark-$\underline{lw_1}$ x Clark-$\underline{lw_1 t}$, which segregated 101 tawny : 37 gray; and Clark-$\underline{lw_1}$ x T176 which segregated 135 tawny : 44 gray. In both populations all tawny plants were non-wavy and all gray plants were wavy.

The proposed genotypes of parent lines are listed below:

| Strain | Leaf | Pubescence | Genotypes |
|---|---|---|---|
| T176 | Wavy | Gray | $\underline{lw_1 lw_2 t}$ |
| Harosoy | Non-wavy | Gray | $\underline{Lw_1 lw_2 t}$ |
| T117 | Non-wavy | Gray | $\underline{lw_1 Lw_2 t}$ |
| Clark | Non-wavy | Tawny | $\underline{Lw_1 lw_2 T}$ |
| Clark-$\underline{lw_1}$ | Non-wavy | Tawny | $\underline{lw_1 lw_2 T}$ |
| Clark-$\underline{lw_1 t}$ | Wavy | Gray | $\underline{lw_1 lw_2 t}$ |
| Clark-$\underline{t}$ | Non-wavy | Gray | $\underline{Lw_1 lw_2 t}$ |

Different levels of waviness of $\underline{lw_1 lw_2}$ plants were observed. They vary from slightly wavy Clark-$\underline{lw_1 t}$, to very wavy T176, with Harosoy-$\underline{lw_1}$ being intermediate. In the hybrid populations, classification was difficult and the inheritance of this variation has not been worked out, although as few as two gene pairs could explain the three levels of waviness.

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8. Inheritance of bullate leaf.

Several years ago at Urbana, plants with abnormal leaves were noticed among segregates of crosses involving T217 (a Korean introduction) and 'Clark'. The leaf was quite rugose, much like one infected with mosaic virus, but with characteristic circular bumps or a blister-like upper surface. The term "bullate," used in plant taxonomy to denote having a blistered or puckered surface, seems to be appropriate for this trait.

Results obtained at Urbana gave evidence that bullate leaf was controlled by two genes with both recessive alleles (here designated $\underline{lb}_1$ and $\underline{lb}_2$) necessary for its expression. Their expression and segregation was independent of the $\underline{T}$-$\underline{t}$ locus (pubescence color).

Complete classification was not possible for crosses with T217, because it contributed severe leafhopper susceptibility and perhaps some mosaic susceptibility. However, in backcross populations in which this susceptibility was gone, the distinction between bullate and non-bullate was readily apparent.

A segregating $F_2$ family from Clark[6] x T217 segregated 3:1 (132 non-bullate : 47 bullate). In the $F_3$ progeny test of 56 non-bullate plants, 12 were true-breeding and 44 segregated 3:1 (666 non-bullate : 227 bullate). All 16 bullate plants tested bred true. We suspected that the heterozygotes in this population were distinguishable as very slightly bullate, and so we classified the "non-bullate" $F_3$ plants from two segregating rows as either completely non-bullate or very slightly bullate. With few exceptions, in the $F_4$ tests the completely non-bullate plants bred true and the very slightly bullate ones segregated. We designated this non-bullate gene in Clark as $\underline{Lb}_1$ and selected a bullate $BC_5$ line, which we designated Clark-$\underline{lb}_1$, that carries the bullate gene $\underline{lb}_1$ from T217.

Since T217 was apparently non-bullate, we suspected that a second gene pair existed. We might have looked for 15:1 ratios in some of the $F_2$ lines of the $BC_1$, but instead we crossed Clark-$\underline{lb}_1$ to T217 and backcrossed to the bullate parent (Clark-$\underline{lb}_1$). In the first three backcrosses to bullate plants, we observed 20 non-bullate and 19 bullate $F_1$ plants, a close fit to the expected 1:1. From non-bullate $F_1$'s of the $BC_1$, we grew an $F_2$ which segregated 3:1 (669 non-bullate : 216 bullate, expected 664:221). We designated this non-bullate gene from T217 as $\underline{Lb}_2$, and the bullate gene from Clark as $\underline{lb}_2$.

We had never observed bullate plants in crosses of T217 and 'Harosoy'. When we crossed Harosoy x Clark-$\underline{lb}_1$, segregation was 15:1 (453 non-bullate : 21 bullate, expected 444:30, $X^2P = .1$); 136 $F_2$ plants were progeny-tested and 68 bred true for non-bullate, 27 segregated 3:1, 30 segregated 15:1, and 11 gave only bullate progeny, a good fit to 7:4:4:1 (expected 60:34:34:9,

$X^2P$ = .3). This cross indicated that Harosoy has both non-bullate genes, $\underline{Lb_1}\underline{Lb_2}$.

Pubescence color ($\underline{T}$-$\underline{t}$) was also segregating in the $F_2$ of Harosoy x Clark-$\underline{lb_1}$. The $F_2$ ratio of 331 tawny non-bullate : 18 tawny bullate : 122 gray non-bullate : 3 gray bullate was observed. This was close to the 45:3:15:1 ratio expected for three independent loci with the 2 leaf genes complementary. The expected numbers, 333:22:111:7, give a $X^2P$ of .2.

The proposed genotypes of parental lines used in this study are listed below:

| Strain | Leaf | Genotype |
|---|---|---|
| T217 | Non-bullate | $\underline{lb_1}\underline{Lb_2}$ |
| Clark | Non-bullate | $\underline{Lb_1}\underline{lb_2}$ |
| Harosoy | Non-bullate | $\underline{Lb_1}\underline{Lb_2}$ |
| Clark-$\underline{lb_1}$ | Bullate | $\underline{lb_1}\underline{lb_2}$ |

M. W. Rode
R. L. Bernard — USDA

9. Inheritance of a sensitive reaction to bentazon herbicide.

In 1971 and 1972, we screened a large number of soybean varieties (338 U.S. and Canadian varieties, and several selected introduced varieties) and found that only 'Hurrelbrink' (a selection from a Korean introduction) and ten Japanese varieties were highly sensitive to moderate rates of foliar applications of bentazon, to which most varieties were highly tolerant. Sensitive varieties exhibited chlorosis and stunting at very low rates and death at moderate rates. Bentazon is a herbicide with considerable potential for selective control of many annual broadleaf weed species in soybeans.

Because of the sharply contrasting reactions, we decided to try to identify the genes involved in control of this. To represent the sensitive phenotypes we chose Hurrelbrink and three Japanese varieties, 'Chinko' (PI 86.504), 'Nookishirohana' (PI 229.342), and 'Kariha Takiya' (PI 243.532), and used 'Clark 63' to represent the tolerant phenotype. Segregating populations were tested by foliar applications of bentazon in the field, greenhouse, and growth chamber, with similar results.

Crosses between sensitive varieties, PI 229.342 x PI 86.504; PI 229.342

x PI 243.532; and PI 229.342 x Hurrelbrink, gave all sensitive $F_2$ plants (about 200 plants tested in each cross).

The $F_2$ of crosses of sensitive with tolerant segregated three tolerant to one sensitive, as tabulated below:

| Cross | Tolerant | Sensitive | Expected | $X^2P$ |
|---|---|---|---|---|
| PI 229.342 x Clark 63 | 461 | 158 | 464.2:154.8 | .8 |
| Clark 63 x PI 86.504 | 467 | 164 | 473.2:157.8 | .7 |
| Clark 63 x PI 243.532 | 349 | 111 | 345:115 | .7 |

In the $F_3$ of PI 229.342 x Clark 63, 49 sensitive $F_2$ plants bred true, 31 tolerant $F_2$'s bred true, and 76 tolerant $F_2$'s segregated 3:1 (1111:390, expected 1125.8:375.2, $X^2P$ = .4).

Thus there is good evidence for control of the bentazon-sensitive reaction by a single recessive gene to which we have assigned the symbol hb. Clark 63 has the allele Hb for the tolerant reaction to the herbicide.

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L. M. Wax — USDA

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1. $E_2$ and $E_3$ maturity gene tests.

Bernard (1971) reported on two major genes, $E_1$ and $E_2$, that affect the time of flowering and maturity of soybeans. Buzzell (1971) reported another maturity gene, $E_3$; the recessive allele did not respond to fluorescent-daylength treatment. Kilen and Hartwig (1971) reported a recessive gene for a similar character in southern varieties.

A number of Illinois backcross-derived lines of 'Clark', which differed in maturity, were classified at Harrow for their fluorescent-daylength response. L63-2404, an early maturing line from Clark[6] x T141, gave an

insensitive response typical of $\underline{e}_3$. An $F_2$ population of L63-3117 ($\underline{e}_2\underline{e}_2$ from Clark[6] x T245) x L63-2404 was grown at Urbana in 1970 and classified for maturity at approximately weekly intervals. The plants were harvested individually. Some $F_3$ plants of each were tested at Harrow for fluorescent-daylength response and some were rated for maturity ($\underline{E}_2/\underline{e}_2$ and $\underline{E}_3/\underline{e}_3$) in the field at Urbana in 1971. There were a few discrepancies between the greenhouse and field ratings for $\underline{E}_3/\underline{e}_3$ but these were clarified by retesting those lines in 1972.

The results (Table 1) confirm that $\underline{E}_3$ is at a different locus than $\underline{E}_2$. A test for independence gave a chi-square value of 8.25 which at 4df has a probability value of .08; thus, we concluded that the two genes segregated independently.

The 1971 plot maturities at Urbana were as follows:

| Strain | Genotype | Average date mature | Days earlier than Clark |
|---|---|---|---|
| L71-920 (Clark-$\underline{e}_2\underline{e}_3$) | $\underline{e}_2\underline{e}_2\underline{e}_3\underline{e}_3$ | Sept. 4 | 30 |
| L63-3117 (Clark-$\underline{e}_2$) | $\underline{e}_2\underline{e}_2\underline{E}_3\underline{E}_3$ | Sept. 10 | 24 |
| L63-2404 (Clark-$\underline{e}_3$) | $\underline{E}_2\underline{E}_2\underline{e}_3\underline{e}_3$ | Sept. 18 | 6 |
| Clark | $\underline{E}_2\underline{E}_2\underline{E}_3\underline{E}_3$ | Oct. 4 | 0 |

$\underline{E}_2$ and $\underline{E}_3$ did not have an equal effect in delaying maturity, and when combined they had less than an additive effect.

Tests for allelism (Table 2) indicated that the gene which Kilen and Hartwig studied in 'Arksoy' and the gene which Buzzell studied in 'Blackhawk' are the same, and that this gene is the same as in L63-2404.

Table 1

Number of $F_2$ plants for each genotype from Clark-$\underline{e}_2\underline{e}_2\underline{E}_3\underline{E}_3$ x Clark-$\underline{E}_2\underline{E}_2\underline{e}_3\underline{e}_3$ (L63-3117 x L63-2404)

| | $\underline{E}_3\underline{E}_3$ | $\underline{E}_3\underline{e}_3$ | $\underline{e}_3\underline{e}_3$ |
|---|---|---|---|
| $\underline{E}_2\underline{E}_2$ | 10 | 11 | 8 |
| $\underline{E}_2\underline{e}_2$ | 16 | 24 | 8 |
| $\underline{e}_2\underline{e}_2$ | 4 | 13 | 3 |

Table 2

Soybean response to natural daylength extended to 20 hours with cool-white fluorescent light

| | No. of plants flowering | | Mean days to flower |
|---|---|---|---|
| | Late | Early | |
| Arksoy | 0 | 6 | 43 |
| Blackhawk | 0 | 6 | 36 |
| L63-2404 (Clark-$e_3$) | 0 | 11 | 38 |
| Arksoy x Blackhawk $F_2$ | 0 | 95 | 37 |
| Blackhawk x L63-2404 $F_2$ | 0 | 135 | 37 |
| L63-2404 x Arksoy $F_2$ | 0 | 115 | 38 |

References

Bernard, R. L. 1971. Two major genes for time of flowering and maturity in soybeans. Crop Sci. 11: 242-244.

Buzzell, R. I. 1971. Inheritance of a soybean flowering response to fluorescent-daylength conditions. Can. J. Genet. Cytol. 13: 703-707.

Kilen, T. C. and E. E. Hartwig. 1971. Inheritance of a light-quality sensitive character in soybeans. Crop Sci. 11: 559-561.

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1. Evidence of a multiple allele for male sterility.

Segregation for male sterility was observed in an $F_3$ row from the cross of L67-533 (Clark-S, short internode) x SRF300 at Urbana, Illinois in 1971. The observed segregation was 63 fertile : 21 sterile (expected 63:21,

assuming sterility controlled by a single recessive gene). This hypothesis was confirmed in 1972, when, totaled over 49 segregating rows, the observed segregation was 1,551 fertile : 528 sterile plants (expected 1,559:520).

Reciprocal crosses were made in 1973 with a source of the North Carolina Male-Sterile (T260), designated as $\underline{ms}_1$ by Brim in 1971, to determine if the UMS (Urbana Male-Sterile) was controlled by the same or different gene for sterility. The UMS, as the female, was crossed with a known heterozygote of (T260 x $L6^5$); and (T260 x $L6^4$), as the female, was crossed with a known heterozygote of UMS (L6 is similar to 'Clark 63' and the backcross lines using T260 were developed by Dr. R. L. Bernard, USDA, University of Illinois). $F_1$ ratios of 10 fertile : 2 sterile were observed for the UMS x T260H cross and 4 fertile : 3 sterile in the reciprocal cross. In the $F_2$ populations from fertile $F_1$ plants, a 322 fertile : 107 sterile (expected 322:107) segregation was observed in the UMS x T260H cross and 190 fertile : 71 sterile (expected 196:65) segregation observed in the T260 x UMS cross. These results indicate that UMS is controlled by a single recessive gene at the same locus as T260 ($\underline{ms}_1$).

Throughout these studies, marked differences in seed set were observed between the UMS and T260. Sterile plants from the UMS tended to have a much higher seed set and frequency of 2- and 3-seeded pods than the T260 sterile plants, which had predominately 1-seeded pods. (Note, this difference was evident even when T260 was backcrossed into the L6 (Clark 63) background. R. L. Bernard, personal communication). In 1974, notes were taken on the distribution of 1-, 2-, and 3-seeded pods on the sterile plants in the reciprocal $F_2$ populations of UMS x T260H, and T260 x UMS. Where UMS was the source of sterility, 35 of the 36 sterile plants had at least one 3-seeded pod. Where T260 was the sterility source, none of the 20 sterile plants had a 3-seeded pod. These results indicate that the UMS is phenotypically distinct from T260 in some environments.

Additional evidence for this phenotypic difference was obtained in the Athens, Georgia, environment in 1974. Out of 20 UMS sterile plants, 17 had 3-seeded pods with a minimum frequency of 36% of the pods being 3-seeded. The three plants without a 3-seeded pod had 1, 3, and 12 pods respectively. By contrast, only 8 out of 20 T260 sterile plants had 3-seeded pods, with a

maximum frequency of 8% of the pods being 3-seeded. Thus, in two diverse environments, the UMS and T260 are phenotypically distinguishable, based on the frequency of 3-seeded pods.

These results indicate that the UMS is controlled by a single recessive gene at the same locus as the T260 gene ($\underline{ms}_1$) but that it may be a different allele in a multiple allelic series. Definitive crosses have been made and segregating populations will be grown in the field in 1975.

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1. Soybean tissue culture studies.

Regeneration of whole plants from cell cultures has been a primary objective. Several cultivars cultured in a liquid medium (Miller, 1965) with 0.5 mg/liter IAA and kinetin and 1.0 mg/liter 2,4-D have developed compact spherical structures, 0.5 to 2.0 mm in diameter, composed of vascular elements enclosed in a compact sheath of parenchyma cells. These structures readily develop roots but not shoots. Altered levels and combinations of plant growth regulators have not promoted shoot differentiation in these cultures.

Fifty-six cultivars of soybeans were screened for the capacity to regenerate whole plants from cell cultures. Callus cultures were initiated from natural, immature embryos 1.0 to 2.0 mm in length on each of four media. Of the cultivars tested, 'NK 9447', 'Hisoy 225', 'SRF 100', and 'Wayne' appeared to demonstrate superior regeneration capacities by developing leaf-like and/or embryo-like structures from callus. These structures, however, deteriorated when subcultured to lower auxin, higher cytokinin media. Callus cultures of these four cultivars initiated from hypocotyl and cotyledon sections of germinated seedlings failed to produce similar organized structures.

The influence of reduced osmotic potentials on callus cultures was studied to determine if large, irregularly shaped callus cells could be modified to conform more closely to typical somatic cells. Reduced osmotic potentials were generated by the addition of mannitol, sorbitol, glucose, and sucrose to the culture medium (Miller, 1965) with 0.5 mg/liter kinetin and IAA. Development of large, irregularly shaped cells was inhibited and callus growth increased when -8 to -12 bars of osmotic tension beyond that of the standard medium was supplied. However, reduction of osmotic potential has not enhanced regeneration of whole plants.

Reference

Miller, Carlos O. 1965. Evidence for the natural occurrence of zeatin and derivatives: compounds from maize which promote cell division. P.N.A.S. 54: 1052-1058.

W. D. Beversdorf
S. L. Kimball
E. T. Bingham

2. Soybean embryo culture studies.

To obtain information of potential usefulness in promoting the embryoids from callus to develop into whole plants, experiments were conducted to find an improved technique and medium for the culture of young natural embryos. Embryos as small as 0.3 mm in diameter across the cotyledons from the embryonic axis were successfully cultured, germinated, and grown into vigorous plants which were eventually transplanted to the greenhouse.

Small embryos were placed beneath the surface of an agar nutrient medium in a loosely capped glass vial. The medium used was a modification of the B5 medium described by Gamborg, Miller and Ojima (1968); the 2,4-D was omitted, 32 mg/liter sodium ferric ethylenediammetetra-acetate was substituted for the sequestrene 330 Fe, the pH was adjusted to 5.8 instead of 5.5, and 8 grams of Difco Bacto-agar was added per liter of medium. The embryos did not germinate on this initial medium but increased in size. After 30 days, the embryos were removed and placed on the surface of a second medium of modified B5, or modified B5 supplemented with 5 mg/liter gibberellic acid.

After 1 to 2 months on this second medium, approximately one-half of the embryos germinated and developed a leafy shoot. The embryos on the gibberellic acid medium developed roots and shoots slightly earlier than those on the basal medium and thus seemed more vigorous. The plantlets were transferred to "Jiffy 7" peat pellets and kept in a humid environment under a tent of cellophane wrap for 2 to 3 weeks under fluorescent lights and a photoperiod of 16 hours, after which they could be handled as natural seedlings.

Reference

Gamborg, O. L., R. A. Miller and K. Ojima. 1968. Nutrient requirements of suspension cultures of soybean root cells. Exp. Cell Res. 50: 151-158.

G. L. Cutter
E. T. Bingham

3. The search for haploid soybeans by using male sterility.

The main objective of the work with the $\underline{ms}_1$ male-sterile gene of soybeans is to obtain haploid plants for genetic and cytogenetic research. A haploid individual was found by Kenworthy, Brim and Wernsman (1973) as a member of a set of twins which was observed among the progeny of $\underline{ms}_1\underline{ms}_1$ male-sterile plants. Seed with the $\underline{ms}_1$ gene was obtained from Brim at North Carolina. Cultivars 'Altona', 'Chippewa 64', 'Corsoy' and 'Hark' were used in crosses and backcrosses to achieve maturity suitable for Wisconsin.

Hand pollinations of male-sterile ($\underline{ms}_1\underline{ms}_1$) plants were made in the greenhouse in the summers of 1973 and 1974. Among 30 seeds obtained and germinated in 1973, one twin set was observed which was a triploid : haploid set. In 1974, 840 crosses were made and 361 seeds were obtained. All except 5 seeds germinated and 20 sets of twins were obtained. To date, 18 of these sets have been examined cytologically and 15 were found to be diploid : diploid, 1 was diploid : triploid, and 2 were diploid : lost. Thus, no haploids have yet been found in 1974.

References

Brim, C. A. and M. F. Young. 1971. Inheritance of a male-sterile character in soybeans. Crop Sci. 11: 564-566.

Kenworthy, W. J., C. A. Brim and E. A. Wernsman. 1973. Polyembryony in soybeans. Crop Sci. 13: 637-639.

G. L. Cutter
E. T. Bingham

4. Soybean aneuploid studies.

We have isolated a group of aneuploid plants from the cultivar 'Dunn'. A plant with 43-44 chromosomes produced four progeny which had chromosome numbers of 40, 40, 41, and 42 respectively. One of the 40-chromosome plants had full fertility and normal morphology. The other 40-chromosome plant was moderately compressed in stature and had lower fertility. This plant produced 27 seeds, of which 13 were shriveled. Analysis of this material has just begun. Two progenies thus far evaluated each have 42 chromosomes. Among the normally-shaped seeds of this 40-chromosome plant, 3 progenies which have been evaluated all have 41 chromosomes.

The 41-chromosome plant of the previous generation was also reduced in stature and highly sterile, producing only 6 small shriveled seeds. All of these seeds have germinated and the progenies are currently being evaluated. The 42-chromosome plant of the previous generation was greatly reduced in size and produced only 1 seed. The resulting progeny is currently under study. It is not yet known if all the trisomics carry the same extra chromosome or if the 42 chromosomes are tetrasomics or double trisomics.

W. D. Beversdorf
E. T. Bingham

# V. INDEX OF CONTRIBUTORS

# VI. GENETIC STOCKS AVAILABLE

## Procedure for Requesting Seeds from the USDA Soybean Germplasm Collection

The USDA maintains a collection of soybean germplasm comprising about 4,000 strains of current and obsolete American varieties, foreign introductions, genetic types, and related species. Seed packets are available for research purposes upon request. The following points are listed to guide you in requesting seeds:

1. Please address requests for early-maturing varieties and PI and FC strains (Maturity Groups 00 to IV), Genetic Types (T-strains), and wild species of Glycine to:

   Dr. R. L. Bernard
   U.S. Regional Soybean Laboratory
   160 Davenport Hall
   Urbana, Illinois 61801
   Tel. 217/333-4639 (FTS 356-1124)

   and requests for late-maturing varieties and PI and FC strains (Groups V to X) to:

   Dr. E. E. Hartwig
   Delta Branch Experiment Station
   Stoneville, Mississippi 38776
   Tel. 601/686-7281, Ext. 230

2. Time of requests:
   Small requests will be filled as soon as possible after receipt. We appreciate advance notice (at least by March 1) on large requests and normally packet these in March-April for planting that season. If you plan to use the seeds at some other time of the year, you should anticipate the need and send us the request by March 1 as we rarely go through the whole collection at other times of the year.

3. Amount of seed:
   a. A standard request is about 50 seeds per packet, but we can easily furnish a smaller number and, if seed supply permits, will also furnish larger amounts. Specify how many you want. If no amount is specified, we will send 50 seeds.

b. Seed counts are only approximate, as we cup the seeds, and only partially compensate for size and germination variation.

c. In the case of named varieties we can sometimes furnish larger amounts, up to a kilogram or so, especially in the case of varieties which we are currently yield testing.

d. The tropical perennial species (all species other than G. max and G. soja) are difficult to grow and reproduce, and normally only a few (5 to 10) seeds will be sent.

4. The following lists and reports are available to assist you in selecting and requesting germplasm.

a. Checklists giving name and maturity group. Extra copies are available to use in making requests for large numbers of strains.

1. Groups 00 to IV varieties, 1973.
2. Groups 00 to IV FC and PI strains, 1973.
3. Groups V to VIII varieties and FC and PI strains, 1967.

b. Evaluation reports giving origin of strains and descriptive, agronomic, and seed composition data:

1. Varieties, Groups 00 to IV, 1970.
2. Varieties, and FC and PI strains, Groups 00-0, 1965.
3. Varieties, and FC and PI strains, Groups I-II, 1966.
4. Varieties, and FC and PI strains, Groups III-IV, 1969.
5. Varieties, and FC and PI strains, Groups V-VIII, 1966.
6. Recent varieties and PI additions, Groups 00-IV, 1970.
7. Genetic Type Collection, 1970.

c. List of wild soybeans, Glycine soja.

d. List of backcross isolines of Clark and Harosoy.

5. Before sending in your request, please verify the accuracy of your strain designations and whether they are maintained at Urbana or Stoneville by checking them against a current checklist or evaluation report. We get many requests for nonexistent varieties and PI's and

you are in a better position than we are to correctly identify what you want.

6. There is no charge for seed for research purposes.

7. We appreciate knowing the intended use of the seeds in all cases and we must know it in the case of very large requests. We also appreciate receiving copies of publications or other information that you derive from the use of these seeds.

March, 1975

Table 1

1. Soybean Isolines

The following is a list of nearly isogenic lines developed by backcrossing. The line column indicates the designation of the specific homozygous line available, usually an $F_2$ or $F_3$ plant progeny. Most lines are selected from the $BC_5$ or from intercrosses between such lines. The superscripts in the parentage column are the number of times that the recurrent parent was crossed to. Disease resistant isolines of Clark and Harosoy were sometimes used in backcrossing, in place of the original varieties. The recurrent parents used and their abbreviations are as follows:

| | | |
|---|---|---|
| Clark | C | Usually the typical subline Clark-L1 |
| L6 | C-$\underline{Rps_1}\,\underline{rxp}$ | A phytophthora and pustule resistant Clark isoline; usually subline L61-5448 |
| L12 | C-$\underline{I}\ \underline{r}\ \underline{Rps_1}\,\underline{rxp}$ | Yellow hilum added to L6; usually subline L64-2244 |
| Harosoy | H | Usually the typical subline Harosoy-L2 |
| L2 | H-$\underline{Rps_1}\,\underline{rxp}$ | Phytophthora and pustule resistant Harosoy isoline, usually subline L61-5047 |
| Chippewa | Ch | |
| Wayne | W | |
| Williams | Wms | |

A seed packet (30 seeds) of each line will be made available for research purposes only, upon request to R. L. Bernard, U.S. Regional Soybean Laboratory, Urbana, IL 61801.

| GENE(S)* | DESCRIPTION | LINE | PARENTAGE |
|---|---|---|---|
| | | CLARK ISOLINES | |
| | | 1. Disease Resistance | |
| Clark = rpm $rps_1$ rxp | | | |
| Rpm* | downy mildew | L70-4170 | L12 x ($C63^5$ x Kanrich) |
| $Rps_1$ | phytophthora rot | L61-4222(L7)† | $C^8$ x Blackhawk |
| $Rps_1$ | " " | L66-180 | PI 101.404 x $C^6$ |
| rxp | bacterial pustule | L61-4180(L8) | $C^8$ x CNS |
| $Rps_1$rxp | | L61-5448(L6) | L8 x L7 |
| $Rps_1$rxp | | L60-246(Clark 63) | ($C^7$ x CNS) x ($C^6$ x Blackhawk) |
| | | 2. Nutrient Response | |
| Clark = Fe np $Rj_1$ | | | |
| fe | iron inefficient | L65-1255 | $C^6$ x T203 |
| Np | phosphorus tolerant | L63-1677 | $C^6$ x Chief |
| Np* | " " | L64-2709 | L6 x ($C^5$ x Chief) |
| $rj_1$ | non-nodulating | L63-1889 | $C^6$ x T201 |
| $rj_1$r* | " " | L73-1054 | L12 x L63-1889 |

†L61-4222 is a subline of L7.

*When the isoline has genes $Rps_1$ and rxp (from L2, L6, or L12) it is indicated by an asterisk in the "Gene" column.

### 3. Stem Growth

Clark = $\underline{Dt_1}\underline{dt_2}\underline{F}\ \underline{s}$

| | | | |
|---|---|---|---|
| $dt_1$ | determinate | L63-3297 | $C^6$ x T141 |
| $dt_1$* | " | L72-1737 | L6 x L63-3297 |
| $dt_1$ | " | L63-3016 | $C^6$ x T245 |
| $Dt_2$ | semi-determinate | L62-1251 | $C^6$ x T117 |
| $Dt_2$* | " " | L73-811 | L6 x L62-1251 |
| f | fasciated | L65-763 | $C^6$ x T248 |
| S | short | L67-592 | $C^6$ x Higan |
| S* | " | L72-1663 | L6 x L67-591(S) |
| $s^t$Np | tall, P-tolerant | L64-1731 | $C^6$ x Chief |
| $dt_1Dt_2$ | | L73-879 | L62-1251($Dt_2$) x L63-3016($dt_1$) |
| $dt_1$S | | L72-1745 | L67-592(S) x " |
| $dt_1s^t$ | | L67-3207 | ($C^6$ x Chief) x L63-3297($dt_1$) |
| $Dt_2$S | | L71-1284 | L67-592(S) x L62-1251($Dt_2$) |
| $Dt_2$S* | | L74-387 | L6 x (L67-592 x L62-1251) |
| $Dt_2s^t$ | | L67-3224 | ($C^6$ x Chief) x L62-1251($Dt_2$) |

### 4. Time of Maturity

Clark = $\underline{e_1}\underline{T}\ \underline{E_2}\underline{E_3}$

| | | | |
|---|---|---|---|
| $E_1$ | late | L67-1474 | $C^6$ x T175 |
| $\widehat{E_1}t$ | late, gray pubescence | L65-3366 | " |
| $\widehat{E_1}t$* | " " " | L72-1630 | L6 x L65-3366 |
| $e_2$ | early | L62-1932 | $C^6$ x T245 |
| $e_2$ | " | L63-3117 | " |
| $e_2$* | " | L72-1495 | L6 x L63-3117 |
| $e_3$ | " | L63-2404 | $C^6$ x T141 |
| $\widehat{E_1}t\ e_2$ | | L66-432 | L62-1932 x L65-3366 |
| $e_2e_3$ | | L71-920 | L63-3117 x L63-2404 |

## 4a. Combinations of Stem and Maturity Genes

| | | |
|---|---|---|
| $dt_1e_2$ | L65-778 | $C^6$ x T245 |
| $dt_1\widehat{E_1t}$ | L66-546 | $(C^6$ x T245$)dt_1e_2$ x L66-3366$(\widehat{E_1t})$ |
| $dt_1\widehat{E_1t}\ e_2$ | L66-531 | " |
| $dt_1\widehat{E_1t}\ e_2$* | L70-4478 | L12 x L66-503(sib of L66-531) |
| $dt_1\widehat{E_1t}\ s^t$ | L72-1903 | L66-531 x L67-3207$(dt_1s^t)$ |
| $dt_1e_2s^t$ | L73-904 | " x L67-3246$(e_2s^t)$ |
| $dt_1\widehat{E_1t}\ e_2s^t$ | L71-1403 | " |
| $Dt_2e_2$ | L67-3232 | L62-1932$(e_2)$ x L62-1251$(Dt_2)$ |
| $Dt_2\widehat{E_1t}$ | L73-980 | L62-1251$(Dt_2)$ x L66-432$(\widehat{E_1t}\ e_2)$ |
| $Dt_2\widehat{E_1t}\ e_2$ | L71-1363 | " |
| $\widehat{E_1t}$ S | L71-1388 | L67-592(S) x L66-432$(\widehat{E_1t}\ e_2)$ |
| $e_2$ S | L71-1374 | " |
| $\widehat{E_1t}\ e_2$S | L71-1378 | " |
| $\widehat{E_1t}\ s^t$ | L72-1893 | L65-3366$(\widehat{E_1t})$ x L64-1731$(s^t$ Np) |
| $e_2s^t$ | L67-3243 | L62-1932$(e_2)$ x (L6 x ($C^5$ x Chief)) |
| $\widehat{E_1t}\ e_2s^t$ | L72-1832 | L66-531$(dt_1\widehat{E_1t}\ e_2)$ x L67-3246$(e_2s^t)$ |

## 5. Leaf Form

Clark = $\underline{Ab}\ \underline{Lb_1}\underline{lb_2}\underline{lf_1}\underline{Lf_2}\ \underline{Ln}\ \underline{Lo}\ \underline{Lw_1}\underline{lw_2}\ \underline{T}$

| | | | |
|---|---|---|---|
| ab* | delayed leaf abscission | L73-1018 | $L6^6$ x Kingwa |
| $lb_1$ | bullate leaf | L65-701 | $C^6$ x T217 |
| $Lf_1$ | five leaflet | L64-1344 | $C^6$ x T245 |
| $Lf_1$* | " " | L72-2157 | L12 x L64-1344 |
| $lf_2$* | seven leaflet | L73-1087 | $L6^6$ x T255 |
| ln | narrow leaflet | L62-1579 | $C^6$ x T204 |
| ln* | " " | L70-4629 | L12 x L62-1579(ln) |

## 5. Leaf Form (continued)

| | | | |
|---|---|---|---|
| lo | oval leaflet | L62-1615 | $C^6$ x T204 |
| $lw_1$ | | L67-1749 | $C^6$ x T176 |
| $lw_1t$ | | L65-600 | " |
| $Lf_1ln$ | | L64-1083 | $(C^6$ x T245$)Lf_1$ x $(C^6$ x T204$)ln$ |
| ln lo | | L70-4313 | $(C^6$ x T204$)ln$ x L62-1615(lo) |

## 6. Pubescence Type

Clark = $\underline{p_1}\ \underline{P_2}\ \underline{Pa_1}\ \underline{Pa_2}\ \underline{pb}\ \underline{Pc}\ \underline{pd}\ \underline{ps}$

| | | | |
|---|---|---|---|
| $P_1$ | glabrous | L62-1385 | $C^6$ x T145 |
| $p_2$ I r* | puberulent | L70-4049 | $L12^6$ x T31 |
| $pa_2$ | non-appressed | L70-4558 | $C^6$ x Higan |
| $pa_1pa_2$ | appressed | L67-497 | " |
| Pb* | sharp tip | L73-1034 | $L6^6$ x Kingwa |
| pc | curly | L63-2435 | $C^6$ x T141 |
| Pd | dense | L62-1686 | $C^6$ x T207 |
| Pd* | " | L73-1046 | L12 x L62-1686 |
| Ps | sparse | L63-2999 | $C^6$ x T240 |
| Ps* | " | L71-149 | L12 x L63-2999 |
| $Ps^s$ | semi-sparse | L64-314 | $C^6$ x Higan |
| $P_1pc$ | | L67-3124 | $(C^6$ x T141$)pc$ x L62-1385$(P_1)$ |
| $P_1pd$ | | L67-3770 | L62-1385$(P_1)$ x $(C^6$ x T207$)Pd$ |
| $P_1Ps$ | | L67-3127 | " x $(C^6$ x T240$)Ps$ |
| $pa_1pa_2pc$ | | L73-1101 | L67-497$(pa_1pa_2)$ x L63-2435(pc) |
| $pa_1pa_2Pd$ | | L73-1118 | " x L62-1686(Pd) |
| $pa_1pa_2Ps$ | | L73-1144 | " x L63-2999(Ps) |
| $pa_1pa_2Ps^s$ | | L67-495 | $C^6$ x Higan |
| $pa_1Ps^s$ | semi-appressed, semi-sparse | L64-326 | " |

## 6. Pubescence Type (continued)

| | |
|---|---|
| $pa_2Ps^s$ | L70-4566 $C^6$ x Higan |
| pc Pd | L65-44 ($C^6$ x T141)pc x ($C^6$ x T207)Pd |
| pc Ps | L65-52 " x ($C^6$ x T240)Ps |
| Pc $Ps^s$ | L68-1864 ($C^6$ x Higan)$Ps^s$ x L63-2435(pc) |
| Pd Ps | L65-90 ($C^6$ x T207)Pd x ($C^6$ x T240)Ps |
| Pd $Ps^s$ | L68-1874 ($C^6$ x Higan)$Ps^s$ x ($C^6$ x T207)Pd |

## 7. Chlorophyll

Clark = cyt-Y g $D_1D_2Y_3Y_7Y_8Y_9Y_{11}$

| | | |
|---|---|---|
| cyt-G | green seed | L62-1027 Medium Green x $C^7$ |
| $d_1d_2$ | " " | L69-4663 $C^6$ x Columbia |
| $d_2$ | no effect | L69-4662 " |
| $G^{(2)}d_1d_2$ | green seed | L64-2545 " |
| $G^{(2)}d_1$ | " " | L69-4659 " |
| G $d_2$ | " " | L69-4666 " |
| $y_3$ | yellow-green plant | L63-2346 $C^6$ x T139 |
| $y_7y_8$ | " " " | L63-1792 $C^6$ x T138 |
| $y_9$* | " " " | L69-4755 $L6^6$ x T135 |
| $Y_{11}y_{11}$ | lethal semi-dom. yellow | L72-1937 $C^6$ x T219 |
| cyt-G $y_3$ | | L64-2584 L62-1027(cyt-G) x ($C^6$ x T139) |

## 8. Pigmentation

Clark = fl $i^i$ im $K_1K_2l_1L_2O$ R T Td $W_1w_3W_4Wm$

| | | |
|---|---|---|
| Fl i* | brown-flecked black seed | L73-1004 L6 x (Clark 63-$i^5$ x T85) |
| I | gray hilum | L62-1058 $C^6$ x T201 |
| i | self black seed | L67-3469 mutation in Clark |
| i* | " " " | L67-3472 mutation in Clark 63 |
| i* | " " " | L66-14 " " " " |

8. Pigmentation (continued)

| | | | |
|---|---|---|---|
| $i^{k}$* | black saddle | L70-4204 | C-i(L66-14)$^{6}$ x Black Eyebrow |
| Im I r* | non-mottled seed | L69-5338 | L12$^{6}$ x Hawkeye |
| Im r* | " " | L69-5366 | " |
| $k_1$ | black saddle | L67-3479 | mutation |
| $k_1$* | " " | L67-3480 | mutation in Clark 63 |
| $k_2$ | tan saddle | L67-3483 | mutation |
| $L_1$* | black pod | L68-1562 | L6$^{6}$ x Seneca |
| $l_2$ | tan pod | L68-1013 | C$^{6}$ x Higan |
| i o r* | red brown seed | L72-2004 | L6-ir(L67-3484)$^{6}$ x Ogemaw |
| r | brown hilum | L62-1383 | C$^{6}$ x T145 |
| r* | " " | L65-1914 | L6 x L11 |
| r Rpm* | " " | L70-4186 | L12 x (Clark 63$^{5}$ x Kanrich) |
| i $r^{m}$ | black and brown stripes | L72-2040 | L67-3484$^{6}$ x T125 |
| t | gray pubescence | L67-483 | C$^{6}$ x Higan |
| td | near-gray pubescence | L66-260 | C$^{6}$ x T240 |
| td* | " " " | L66-228 | L6$^{6}$ x Sooty |
| td* | " " " | L70-4404 | L6$^{6}$ x Grant |
| $w_1$ | white flower | L63-2373 | C$^{6}$ x T139 |
| $w_1$* | " " | L69-4776 | L6$^{6}$ x Seneca |
| $W_3W_4$* | purple throat flower | L70-4422 | L6$^{6}$ x (Laredo x Harosoy) |
| $w_4$* | near-white flower | L68-1774 | " |
| wm* | magenta flower | L72-2181 | L6$^{6}$ x T235 |
| I r | yellow hilum | L64-2191(L11) | (C$^{6}$ x T201)I x (C$^{6}$ x T145)r |
| I r* | " " | L64-2244(L12) | L6 x L11(I r) |
| I r Rpm* | " " | L70-4191 | L12 x (Clark 63$^{5}$ x Kanrich) |
| I r t* | | L70-4543 | L12$^{6}$ x Hawkeye |

| | | | |
|---|---|---|---|
| I r t $w_1$* | | L68-2056 | L12 x L64-2279(t $w_1$) |
| $i^k$ r o | | L74-1089 | (C63-$i^6$ x Black Eyebrow)$i^k$ x (L67-3484 i $r^5$ x Ogemaw) i o r |
| i r | | L66-17 | mutation in L11 |
| i r* | | L67-3484 | C63-i x L12 |
| i t | | L68-2073 | L67-3469(i) x ((C$^6$ x T139)$w_1$ x (C$^6$ x T204)t) |
| i t $w_1$ | | L70-4497 | " |
| i $w_1$ | | L68-2077 | " |
| $k_1$ $t_1$ | imp. black saddle | L68-2082 | L67-3479($k_1$) x " |
| $k_1$ $w_1$ | black saddle | L68-2085 | " |
| $k_1$ t $w_1$ | buff saddle | L68-2093 | " |
| $k_1$ r | brown saddle | L68-2106 | " x L12(I r) |
| I $k_1$ | near self black | L68-2130 | " |
| I $k_1$ r | near self brown | L68-2105 | " |
| $l_2$t | | L68-1017 | C$^6$ x Higan |
| $l_2w_1$ | | L69-4814 | C$^6$ x T204 |
| r $w_1$* | | L68-2061 | L12 x ((C$^6$ x T139)$w_1$ x (C$^6$ x T204)t) |
| r t $w_1$* | | L68-2063 | " |
| t $w_1$ | | L64-2281 | (C$^6$ x T139)$w_1$ x (C$^6$ x T204)t |
| t td | | L73-1071 | L67-483(t) x L66-228(td) |
| td $w_1$* | | L69-4775 | L6$^6$ x Seneca |
| wm t* | | L72-2210 | L6$^6$ x T235 |

## 9. Miscellaneous

| | | | |
|---|---|---|---|
| Gracilis cytoplasm | | L68-1306 | PI 65.388 x $C^6$ |
| Wild cytoplasm | | L66-183 | PI 101.404 x $C^6$ |
| " " | | L67-1189 | PI 101.404B x $C^6$ |
| $B_1$i | bloom on seed | L69-4544 | C-$i^6$ x Sooty |
| $d_1d_2p_2$* | | L72-2824 | ($L12^6$ x T31) x ($C^6$ x Columbia)$d_1d_2$ |
| $d_1d_2p_2$I r* | | L72-2832 | " |
| $dt_1\widehat{E_1t}$ $e_2$I r* | | L72-944 | ($L12^6$ x Hawkeye) x L66-531 |
| $dt_1\widehat{E_1t}$ $e_2$Im* | | L72-1853 | " |
| $dt_1\widehat{E_1t}$ $e_2$Pd | | L72-1885 | L66-531 x L62-1686(Pd) |
| $dt_1e_2Lf_1$ | | L65-774 | $C^6$ x T245 |
| $dt_1Lf_1$ | | L63-3022 | " |
| $dt_1L_1$ | | L72-1727 | ($L6^6$ x Seneca)$L_1$ x L63-3297($dt_1$) |
| $Dt_2Lf_1$ | | L64-1081 | ($C^6$ x T117)$Dt_2$ x ($C^6$ x T245)$Lf_1$ |
| $Dt_2Lf_1$ln | | L68-2040 | L64-1074($Dt_2$ln) x " |
| $Dt_2$ln | | L64-1074 | ($C^6$ x T117)$Dt_2$ x ($C^6$ x T204)ln |
| $\widehat{E_1t}$ $e_2$Pd | | L72-1879 | L66-531($dt_1\widehat{E_1t}$ $e_2$) x L62-1686(Pd) |
| $e_2$I r* | | L73-760 | L6 x ($L12^5$ x Hawkeye) |
| $e_2$Im* | | L72-1582 | " |
| $e_2$ I Im r* | | L73-753 | " |
| $e_2Lf_1$ | | L64-1316 | $C^6$ x T245 |
| $e_2$t* | | L72-1568 | $L6^6$ x T235 |
| $e_2$wm* | | L72-1566 | " |
| I $\widehat{P_1r}$ | | L68-2045 | L62-1058(I) x ($C^6$ x T145)$\widehat{P_1r}$ |
| I r $rj_1$* | | L72-2133 | L12 x L63-1889($rj_1$) |
| ln I r* | | L72-2111 | L12 x L62-1579(ln) |
| ln t | | L62-1568 | $C^6$ x T204 |

## 9. Miscellaneous (continued)

| | | | |
|---|---|---|---|
| lo I r* | | L70-4611 | L12 x L62-1615(lo) |
| $Ms_1ms_1$ | male-sterile | L74-03 | $L6^6$ x T260H |
| n* | abnormal hilum | L72-1987 | $L6^6$ x Soysota |
| n r* | | L72-1977 | " |
| $\widehat{P_1r}$ | | L62-1377 | $C^6$ x T145 |
| $pa_1pa_2S$ | | L67-509 | $C^6$ x Higan |

# HAROSOY ISOLINES

## 1. Disease Resistance

Harosoy = $\underline{rps_1}\,\underline{rps_2}\,\underline{Rxp}$

| | | | |
|---|---|---|---|
| $Rps_1$ | phytophthora rot | L59-731 | $H^8$ x Blackhawk |
| $Rps_2$ | " " | L70-6494 | $H^5$ x D54-2437 |

(D54-2437 parentage is Roanoke, Ogden, CNS, Lincoln, and Richland; $Rps_2$ is presumably from CNS.)

| | | | |
|---|---|---|---|
| rxp | bacterial pustule | L61-4094(L3) | $H^6$ x S54-1207 |
| $Rps_1$rxp | | L61-5047(L2) | Harosoy 63 x L3 |
| $Rps_1$rxp | | L68-758 | $H^4$ x L2 |

## 2. Nutrient Response

Harosoy = $\underline{Fe}\,\underline{np}\,\underline{Rj_1}$

| | | | |
|---|---|---|---|
| fe | iron inefficient | L66-731 | $H^6$ x T203 |
| Np | phosphorus tolerant | L66-704 | $H^6$ x ($C^6$ x Chief) |
| $rj_1$ | non-nodulating | L65-1274 | $H^6$ x T201 |
| $rj_1$* | " " | L66-2470 | L2 x ($H^6$ x T201) |

## 3. Stem Growth

Harosoy = $\underline{Dt_1}\underline{dt_2}$ $\underline{F}$ $\underline{s}$

| | | | |
|---|---|---|---|
| $dt_1$ | determinate | L67-153 | $H^6$ x Higan |
| $dt_1$ | " | L62-973 | $H^6$ x T245 |
| $dt_1$* | " | L72-1177 | L2 x ($H^6$ x T145) |
| $Dt_2$ | semi-determinate | L62-364 | H6 x T117 |
| $Dt_2$* | " " | L67-1250 | L2 x ($H^6$ x T117) |
| $Dt_2$ | " " | L63-1397 | $H^6$ x T207 |
| f | fasciated | L65-756 | $H^6$ x T248 |
| S | short | L67-234 | $H^6$ x Higan |
| S* | " | L72-1198 | L2 x L67-234 |
| $dt_1Dt_2$ | | L67-3256 | ($H^6$ x T117)$Dt_2$ x L62-973($dt_1$) |
| $dt_1$S | | L72-1228 | L67-234(S) x L67-153($dt_1$) |
| $Dt_2$S | | L72-1241 | " x L63-1397($Dt_2$) |
| $Dt_2$S* | | L73-105 | (L2 x L67-234) x (L2 x ($H^6$ x T117)) |

## 4. Time of Maturity

Harosoy = $\underline{e_1}\underline{t}$ $\underline{e_2}$ $\underline{E_3}$

| | | | |
|---|---|---|---|
| $E_1$ | late | L68-694 | $H^6$ x T217 |
| $\widehat{E_1T}$ | late, tawny pubescence | L67-2324 | " |
| $\widehat{E_1T}$* | " " " | L72-1304 | L2 x L67-2324 |
| $e_3$ | early | L73-1543 | $H^6$ x T204 |
| $\widehat{E_1T}$ $e_3$ | | L71-802 | ($H^6$ x T204)$e_3$ x L67-2324 |

## 5. Leaf Form

Harosoy = $\underline{Ab}$ $\underline{lf_1}\underline{Ln}$ $\underline{Lo}$ $\underline{Lw_1}\underline{lw_2}$

| | | | |
|---|---|---|---|
| ab* | delayed leaf abscission | L73-67 | $L2^6$ x Kingwa |
| $Lf_1$ | five leaflet | L62-956 | $H^6$ x T245 |
| ln | narrow leaflet | L63-1212 | $H^6$ x T204 |

## 5. Leaf Form (continued)

| | | | |
|---|---|---|---|
| lo | oval leaflet | L65-372 | $H^6$ x T204 |
| $lw_1$ | wavy leaf | L65-461 | $H^6$ x T176 |
| $Lf_1$ ln | | L64-1069 | $(H^6$ x T245$)Lf_1$ x $(H^6$ x T204)ln |
| ln lo | | L70-4136 | $(H^6$ x T204)ln x $(H^6$ x T204)lo |

## 6. Pubescence Type

Harosoy = $\underline{p_1}\,\underline{P_2}\,\underline{Pa_1}\,\underline{Pa_2}\,\underline{pb}\,\underline{Pc}\,\underline{pd}\,\underline{ps}$

| | | | |
|---|---|---|---|
| $P_1$ | glabrous | L62-561 | $H^6$ x T145 |
| $p_2$* | puberulent | L70-4001 | $L2^6$ x T31 |
| $pa_1$ | semi-appressed | L67-271 | $H^6$ x Higan |
| $pa_2$ | non-appressed | L70-4119 | " |
| $pa_1pa_2$ | appressed | L69-6095 | " |
| Pb* | sharp tip | L73-79 | $L2^6$ x Kingwa |
| pc | curly | L63-1097 | $H^6$ x T141 |
| Pd | dense | L62-801 | $H^6$ x T207 |
| Pd* | " | L71-46 | L2 x L62-801 |
| Ps | sparse | L62-880 | $H^6$ x T240 |
| $Ps^s$ | semi-sparse | L67-166 | $H^6$ x Higan |
| $P_1$pc | | L67-3099A | $(H^6$ x T141)pc x L62-561$(P_1)$ |
| $P_1$Pd | | L67-3101A | $(H^6$ x T207)Pd x " |
| $P_1$Ps | | L67-3104B | $(H^6$ x T240)Ps x " |
| $pa_1Ps^s$ | | L65-237 | $H^6$ x Higan |
| pc Pd | | L65-25 | $(H^6$ x T141)pc x $(H^6$ x T207)Pd |
| pc Ps | | L65-34 | " x $(H^6$ x T240)Ps |
| Pd Ps | | L65-60 | $(H^6$ x T240)Ps x $(H^6$ x T207)Pd |

Harosoy = cyt-Y g $D_1D_2Y_3Y_7Y_8Y_9$

| | |
|---|---|
| cyt-G | green seed |
| $d_1d_2$ | " " |
| $d_1$ | no effect |
| $d_2$ | " " |
| $\widehat{G}\ d_1d_2$ | green seed |
| $\widehat{G}\ d_1$ | green seed coat |
| G $d_2$ | " " " |
| $y_3$ | yellow-green plant |
| $y_7y_8$ | " " |
| $y_9$* | " " |

Harosoy = I $K_2l_1L_2r$ t $W_1w_3W_4Wm$

| | |
|---|---|
| $i^i$ | buff hilum |
| i | self buff seed |
| i* | " " " |
| $k_2$ | tan saddle |
| $L_1$* | black pod |
| $l_2$ | tan pod |
| R | gray hilum |
| T | tawny pubescence |
| $w_1$ | white flower |
| $W_3w_4$* | purple throat flower |
| $w_4$* | near-white flower |
| wm | magenta flower |
| wm Rps | " " |
| $i^i$ R | imperfect black hilum |

7. Chlorophyll

| | |
|---|---|
| L62-17 | Medium Green x $H^7$ |
| L69-4267 | $H^6$ x Columbia |
| L73-54 | L69-4268($\widehat{G}\ d_1$) x L69-4267($d_1d_2$) |
| L69-4266 | $H^6$ x Columbia |
| L64-2489 | " |
| L69-4265 | " |
| L67-971 | " |
| L63-1016 | $H^6$ x T139 |
| L68-560 | $H^6$ x T138 |
| L69-4318 | $L2^6$ x T135 |

8. Pigmentation

| | |
|---|---|
| L67-38 | $H^6$ x Clark |
| L67-3388 | mutation |
| L67-3396 | mutation in L2 |
| T239 | mutation |
| L68-582 | $L2^6$ x Seneca |
| L67-226 | $H^6$ x Higan |
| L65-540 | $H^6$ x T176 |
| L66-707 | $H^6$ x Clark |
| L62-906 | $H^6$ x T240 |
| L72-1078 | $L2^6$ x Laredo |
| L72-1138 | " |
| T235 | mutation |
| L63-1612 | Harosoy 63 x ($T235^2$ x ($H^5$ x Blackhawk)) |
| L67-1695 | $H^6$ x T176 |

## 9. Miscellaneous

| | | | |
|---|---|---|---|
| $Dt_2i^i$ | | L65-1058 | $H^6$ x T117 |
| $\overset{\frown}{G}d_1d_2(E_1?)$ | | L64-2511 | $H^6$ x Columbia |
| $i^i$ Np | | L66-721 | $H^6$ x L9(C-Np) |
| $i^i$ R $lw_1$ | | L67-1687 | $H^6$ x T176 |
| $l_2P_1$ | | L62-558 | $H^6$ x T145 |
| $l_2S$ | | L67-225 | $H^6$ x Higan |
| n* | abnormal hilum | L72-1140 | $L2^6$ x Soysota |
| Np T | | L66-713 | $H^6$ x L9(C-Np) |
| $d_1d_2p_2$* | | L70-4037 | $(L2^5$ x T31$)p_2$ x $(H^6$ x Columbia$)d_1d_2$ |
| $dt_1\overset{\frown}{E_1}T$ | | L71-1111 | L67-2324($\overset{\frown}{E_1}$T) x L67-153($dt_1$) |
| $Dt_2\overset{\frown}{E_1}T$ | | L73-184 | " x L63-1397($Dt_2$) |
| $Dt_2Lf_1$ | | L64-1067 | $(H^6$ x T117$)Dt_2$ x $(H^6$ x T245$)Lf_1$ |
| $Dt_2ln$ | | L64-1061 | " x $(H^6$ x T204$)ln$ |
| $Dt_2Lf_1ln$ | | L67-3298 | L64-1061($Dt_2ln$) x L64-1067($Dt_2Lf_1$) |
| $\overset{\frown}{E_1}T$ S | | L71-1106 | L67-234(S) x L67-2324($\overset{\frown}{E_1}$T) |

## CHIPPEWA ISOLINES

| | | | |
|---|---|---|---|
| $Rps_1$ | phytophthora rot res. | L63-16 | $Ch^{10}$ x Blackhawk |
| rxp | bacterial pustule res. | L63-42 | $Ch^8$ x CNS(et al.) |
| $Rps_1$ rxp | | L64-2721(L10)† | $(Ch^8$ x CNS$)$ x $(Ch^{10}$ x Blackhawk$)$ |
| Rpm* | downy mildew res. | L68-4172(SL7) | $L10^8$ x Kanrich |

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*Also $\underline{Rps_1}$ $\underline{rxp}$ by using L10 as recurrent parent.

†This indicates L64-2721 is a subline of L10.

## CHIPPEWA ISOLINES (continued)

| | | | |
|---|---|---|---|
| I r* | yellow hilum | L66-892(L16) | $L10^6$ x Clark-I r (L11) |
| $\widehat{P_1}$r* | glabrous, brown hilum | L67-3583 | $L10^6$ x Clark-I $\widehat{P_1}$r |
| I $\widehat{P_1}$r* | " yellow hilum | L67-3586B | " |
| r Rpm* | brown hilum, d.m. res. | L68-4188 | $L10^8$ x Kanrich |
| I r Rpm* | yellow hilum, " " | L68-4216(SL8) | L16 x ($L10^8$ x Kanrich) |
| I t $w_1$Rpm* | " " " " | L68-4242 | $L10^5$ x S62X30:1‡ |
| $E_2$* | late | L68-4291 | $L10^6$ x Clark |

*Also $\underline{Rps_1}$ $\underline{rxp}$ by using L10 as recurrent parent.

‡[$C^2$ x (Lincoln$^2$ x Richland)] I t w x (Clark $63^3$ x Kanrich) $\underline{Rpm}$ $\underline{Rps_1}$ $\underline{rxp}$.

## WAYNE ISOLINES

| | | | |
|---|---|---|---|
| $Rps_1$ | phytophthora rot res. | L65-4059(L15) | $W^6$ x Clark 63 |
| Rpm | downy mildew res. | L68-4064(SL9) | $W^{10}$ x Kanrich |
| Rpm $Rps_1$ | | L69-4124(SL10) | L65-4059 x SL9 |
| Rpm $Rps_1$ | | L72-1419 | " |
| I r | yellow hilum | L66-949(L20) | $W^5$ x Clark-I $\widehat{P_1}$r(L63-3534) |
| I $i^i$ $\widehat{P_1}$r | glabrous | L67-3522 | " |
| I r $Rps_1$ | | L67-3542 | L15 x ($W^4$ x C-I $\widehat{P_1}$r) |
| r Rpm $Rps_1$ | brown hilum | L69-4143(SL11) | L67-3526†(I r $Rps_1$) x SL9 |
| I r Rpm $Rps_1$ | yellow hilum | L69-4180(SL12) | " |

†Sib of L67-3542.

## WAYNE ISOLINES (continued)

| | | | |
|---|---|---|---|
| I r Rpm $Rps_1$ | | L72-1424 | L67-3526[†](I r $Rps_1$) x SL12 |
| Im r Rpm $Rps_1$ | non-mottling | L72-1362 | $SL12^6$ x Merit |
| Im I r Rpm $Rps_1$ | " | L73-212 | " |
| ln I r Rpm $Rps_1$ | narrow leaf | L72-1369 | $SL12^6$ x Clark-ln |
| $e_2$ I r Rpm $Rps_1$ | early | L72-1401 | $SL12^6$ x Clark-$e_2$ |

[†]Sib of L67-3542.

## WILLIAMS ISOLINE

| | | | |
|---|---|---|---|
| $Ms_2ms_2$ | male-sterile | L74-01 | $Wms^6$ x T259H |

Table 2

Soybean Isolines

The following is a list of nearly isogenic lines developed by backcrossing. D49-2491 is a sister line of Lee (Maturity Group VI) which differs from Lee in being less susceptible to downy mildew. Four to six backcrosses were used with D49-2491 as the recurrent parent. For plantings made in May at Stoneville, Mississippi, D49-2491 will mature approximately October 16. It has purple flowers, tawny pubescence, tan pod wall, and a determinate growth habit. It has a high level of resistance to bacterial pustule, frogeye leafspot, target spot, and field resistance to phytophthora rot.

A seed packet (30 seeds) of each line will be made available for research purposes only, upon request to E. E. Hartwig, Delta Branch Experiment Station, Stoneville, MS 38776.

| Descriptive designation | Line | Parentage |
|---|---|---|
| High oil from a low oil parent | D62-7802 | PI 174.862 |
| High oil from a high oil parent | D62-7803 | L43-2010 [C167(Midwest x Dunfield) x L37-1355 (rogue in PI 81.041)] |
| Medium protein | D62-7805 | PI 174.862 |
| High protein | D62-7806 | PI 174.862 |
| Glabrous, resistant to phytophthora rot — $\underline{P_1}\underline{Rps_1}$ | D62-7812 | PI 200.532 |
| Susceptible to bacterial pustule — $\underline{Rxp}$ | D62-7814 | PI 200.532 |
| Glabrous from very early maturing parent — $\underline{P_1}$ | D62-7815 | PI 181.537 |
| Narrow leaf — $\underline{ln}$ | D62-7816 | PI 181.537 |
| Indeterminate growth — $\underline{Dt_1}$ | D62-7817 | PI 174.862 |
| Dense pubescence — $\underline{Pd}$ | D62-7820 | Majos |
| White flower, gray pubescence, buff hilum — $\underline{wt}$ | D62-7818 | Dorman |
| Curly pubescence — $\underline{pc}$ | D64-8707 | L47-163 [PI 84.987 (T141) x PI 88.351] |
| Oval leaf, low number seeds per pod — $\underline{lo}$ | D63-3933 | T122 |
| Group VII maturity | D61-4269 | Barchet |

| Descriptive designation | Line | Parentage |
|---|---|---|
| Small seed — 9g/100 | D59-2537 | PI 165.926 |
| Large seed — 25g/100 | D65-6792 | Rokusun |
| Non-nodulating — $\underline{rj}_1$ | D66-0099 | T181 |
| Extra narrow leaf — $\underline{ln}$ $\underline{lo}$ | D66-11016 | D62-7816 x D63-3933 |
| Narrow leaf, high number of seeds/pod — $\underline{ln}$ | D63-7203 | T109 |
| High oil from a low oil parent | D62-7809 | Biloxi |

# VII. RECENT SOYBEAN GENETICS AND BREEDING PUBLICATIONS

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# VIII. RESEARCH ACTIVITIES

| Name and Address | Research Interest |
|---|---|
| J. W. Turner<br>P.O. Box 23<br>Kingaroy, Q. 4610<br>AUSTRALIA | Plant-insect interrelationships. |
| J. M. Vincent<br>UNSW P.O. Box 1<br>Kensington, N.S.W.<br>AUSTRALIA 2033 | Inheritance of nodulating capacity; editor of Rhizobium Newsletter. |
| Gaspar Beskow<br>Departamento de Melhoramento de Soja<br>CEP - FECOTRIGO<br>Cx. Postal 10<br>98.100 - Cruz Alta, RS-BRAZIL | Soybean breeding for increased yield, height, lodging resistance, and response to Al and Mn toxicity; competition among cultivars; variety testing with maturity groups from VI to VIII. |
| Ake Boklin<br>Caixa Postal 673<br>13100-Campinas, S.P.<br>BRAZIL | Plant breeding; seeking day-neutral soybean; working with Group VIII soybeans. |
| Luiz Pedro Bonetti<br>Departamento de Melhoramento de Soja<br>CEP - FECOTRIGO<br>Caixa Postal 10<br>98.100 - Cruz Alta, RS-BRAZIL | Breeding soybeans for southern Brazil with emphasis on maturity groups adapted to the latitudes between 28° - 32° S; disease resistance; good agronomic types; and transferring high protein and oil content into adapted varieties by multiple crosses. |
| H. L. Gabe<br>CMNDP — Maringá Office<br>R. São Bento, 329-8° andar<br>Caixa Postal 2771<br>São Paulo, BRAZIL | In charge of soybean program for International Plant Breeders in Brazil. |
| T. Ashley<br>Dept. of Biology<br>University of Calgary<br>Calgary, Alberta, CANADA | Soybean genetics, chromosome association and crossing over. |
| D. A. Littlejohns<br>Farm Crops Section<br>College of Agr. Technology<br>Ridgetown Ontario NOP 2CO<br>CANADA | Variety evaluation and production studies in soybeans |

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| Waldo A. Cerón-Díaz<br>Facultad de Agronomía<br>Casilla 114-D<br>Santiago de CHILE | Teaching field crops production and production of industrial crops, research on soybeans and safflower. |
| Cecil Vera Roldán<br>Ingeniero Agrónomo<br>Casilla 426, Chillán, CHILE | Soybean development at Quilamapu Experimental Station, Chillán, Chile. |
| W. Plarre<br>Freie Universitat Berlin<br>Albrecht-Thaer-Weg 6<br>FB23, WE6, 1000 Berlin 33<br>GERMANY | Soybean breeding. |
| Bálint Andor<br>Agrártudományi Egyetem<br>Novenynemesitestani tanszek<br>2103 Godöllö<br>Budapest, HUNGARY | Using mostly American soybean varieties, developing mutants with better adaptability to conditions in Hungary. |
| Nabinananda Ghosh<br>Dept. of Crop Science<br>Hokkaido University<br>Kita 9 Jo, Nishi 9 Chome<br>Kita Ku, Sapporo, JAPAN 060 | Quantitative genetics of soybeans. |
| Koji Hashimoto<br>Hokkaido Nat. Agr. Exp. Sta.<br>Hitsujigaoka, Toyohira-ku<br>Sapporo, 061-01 JAPAN | Low temperature injury and nitrogen nutrition of soybeans. |
| K. Hayashi<br>Division of Genetics<br>Nat'l. Inst. of Agr. Sciences<br>Hiratsuka, Kanagawa, JAPAN 254 | Genetic variation in soybean germplasm resources. |
| Norihiko Kaizuma<br>Plant Breeding Lab.<br>Faculty of Agriculture<br>Iwate University<br>Ueda, Morioka, Iwate-ken<br>JAPAN 020 | Soybean protein breeding, especially sulfur-containing amino acids. |
| Shigeo Matsumoto<br>Kariwano Laboratory<br>Tohoku Nat'l. Agr. Exp. Sta.<br>Nishisenboku, Akita 019-21<br>JAPAN | Breeding for nematode and virus resistance in soybeans. |

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| Masataka Saito<br>Hokkaido Central Agr. Exp. Sta.<br>Naganuma, Yubari-gun<br>Hokkaido, JAPAN | Breeding of soybeans for: high and stabilized seed yield, high quality seed, low temperature tolerance, cyst nematode resistance, soybean dwarf virus resistance. |
| Kiyoshi Sunada<br>Tokachi Agr. Exp. Sta.<br>Memuro-cho, Kasai-gun<br>Hokkaido, JAPAN | Breeding for high yield and wide adaptation, cold weather tolerance, resistant to cyst nematode, and chemical composition in seed. |
| T. Yamamoto<br>Hokkaido Nat'l. Agr. Exp. Sta.<br>Sapporo, JAPAN 061-01 | Physiological research for cool weather injury of soybeans. |
| William M. Brown, Jr.<br>Inst. of Plant Environment<br>Suweon, 170, KOREA | Soybean pathology; soybean disease survey. |
| Hong Suk Lee<br>Department of Agronomy<br>College of Agriculture<br>Seoul National University<br>Suweon, KOREA | Breeding for physiological attributes in soybean. |
| Javier Icaza G.<br>Cubra Development<br>León, NICARAGUA<br>Central America | Soybean experimentation, crops management including irrigation and pest control. |
| D. Nangju<br>IITA<br>PMB 5320<br>Ibadan, NIGERIA | Cultural practices and crop management in soybeans. |
| J. N. Singh<br>Department of Agronomy<br>G.B. Pant Univ. of Agr. & Tech.<br>Pantnagar, Nainital, INDIA | Soybean seed technology and soybean physiology. |
| E. H. Paschal II<br>INTSOY (Univ. of Illinois)<br>Department of Agronomy<br>University of Puerto Rico<br>Mayagüez, PUERTO RICO 00708 | Breeding of soybean varieties which are adapted to tropical and subtropical environments. |
| J. R. Tattersfield<br>Principal Plant Breeder<br>Salisbury Research Station<br>P.O. Box 8100, Causeway<br>Salisbury, RHODESIA | Soybean breeding. |

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| S. Shanmugasundaram<br>Asian Vegetable Research & Development Center<br>P.O. Box 42, Shanhua<br>Tainan (741), TAIWAN | Breeding for high yield potential, photoperiod insensitivity, and multiple disease resistance. Special emphasis on soybean rust resistance. |
| Kuo-Hai Tsai<br>Food Crop Research Institute<br>National Chung-Hsing Univ.<br>Taichung, TAIWAN | Breeding for ecological attributes in soybean. |
| Charles Y. Yang<br>Asian Vegetable Research and Development Center<br>P.O. Box 42, Shanhua<br>Tainan, 741, TAIWAN | Breeding for resistance to Phakopsora pachyrhizi rust. |
| Sumin Smutkupt<br>Radiation and Isotopes Section<br>Kasetsart University<br>Bangkok, THAILAND | Soybean varietal improvement; soybean mutation breeding. |
| Edgardo Monteverde P.<br>Departamento de Genética<br>Facultad de Agronomia<br>Maracay, VENEZUELA | Breeding for tropical adaptation. |
| W. L. Chang<br>Leader, Chinese Rice Mission<br>P.O. Box 143, HOFUF<br>SAUDI ARABIA | Studying possibility of raising soybeans in saline soil of Al-Hassa Oasis. |
| Nguyen H. Quyen, Head<br>Department of Agronomy<br>Faculty of Agriculture<br>National University of Cantho<br>Cantho, S. VIETNAM | Breeding for yield; for insect and disease resistance, and drought tolerance in soybeans. |
| David D. Rubis<br>Dept. of Agron. & Plant Genetics<br>University of Arizona<br>Tucson, AZ 85721 | Breeding for shattering resistance and heat tolerance in soybeans. |
| H. W. Crittendon<br>University of Delaware<br>Newark, DE 19711 | Studying the pathology of soybeans. |
| N. C. Schenck<br>Plant Pathology Department<br>University of Florida<br>Gainesville, FL 32611 | Soil-borne plant pathogens and endomycorrhizal fungi on soybean roots. |

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| Jack Paxton<br>Dept. of Plant Pathology<br>University of Illinois<br>Urbana, IL 61801 | Physiology and biochemistry of soybean disease resistance and nodulation. |
| Louis Bellatti<br>Bellatti Soybeans<br>Mt. Pulaski, IL 62548 | Breeding in natural crossing, mutation, population control. |
| Donald Lindahl<br>Pioneer Hi-Bred Intnat'l., Inc.<br>Peterson Soybean Seed Division<br>Drawer F<br>St. Joseph, IL 61873 | Development of proprietary varieties with major emphasis on group II through IV. Breeding has been started in the group V through VIII. Breeding for improved yield, seed quality, vigor, and resistance to phytophthora root rot, bacterial pustule, and downy mildew. |
| J. E. Harper<br>USDA-ARS<br>University of Illinois<br>Urbana, IL 61801 | Mineral nutrition and nitrogen metabolism of soybeans. |
| T. Hymowitz<br>Department of Agronomy<br>University of Illinois<br>Urbana, IL 61801 | Soybean genetics, and biochemistry of seed proteins; ethnobotany of soybeans and related legume crops. |
| Oval Myers, Jr.<br>Dept. of Plant and Soil Science<br>S.I.U. at Carbondale<br>Carbondale, IL 62901 | Soybean genetics and improvement, in relation to work in Brazil. |
| L. M. Wax<br>Agronomy Department<br>230 Davenport Hall<br>University of Illinois<br>Urbana, IL 61801 | Developing improved methods of weed control in soybeans. |
| J. M. Widholm<br>Department of Agronomy<br>University of Illinois<br>Urbana, IL 61801 | Mutation induction and photorespiration screening in soybeans. |
| H. R. Koller<br>Department of Agronomy<br>Purdue University<br>West Lafayette, IN 47907 | Physiological determinants of soybean seed yield. |
| F. A. Laviolette<br>Dept. of Botany and Plant Path.<br>Purdue University<br>West Lafayette, IN 47907 | Host relationships, disease control and seed quality. |

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| G. Robert Taylor<br>Soybean Breeder<br>FFR Cooperative<br>4112 East State Road 225<br>West Lafayette, IN 47906 | Varietal development for member cooperatives. Breeding for yield, adaptation and disease resistance. |
| William H. Eby<br>Midwest Oilseeds, Inc.<br>Adel, IA 50003 | Breeding for yield improvement and disease resistance. |
| J. M. Dunleavy<br>Dept. of Botany and Plant Path.<br>Iowa State University<br>Ames, IA 50010 | Soybean host-parasite interactions. |
| D. Green<br>Department of Agronomy<br>Iowa State University<br>Ames, IA 50010 | Breeding for physiological attributes in soybeans. |
| Reid G. Palmer<br>USDA-ARS<br>Agronomy Department<br>Iowa State University<br>Ames, IA 50010 | Cytogenetics, physiological genetics, qualitative genetics, chromosome mapping, interspecific hybridization. |
| Larry P. Pedigo<br>Department of Entomology<br>Iowa State University<br>Ames, IA 50010 | Pest management of soybean insects; evaluation of commercial varieties for green cloverworm resistance. |
| T. E. Devine<br>Room 236, Bldg. 007, BARC-W<br>USDA-ARS<br>Beltsville, MD 20705 | Genetics of soybean x *Rhizobium* interaction in nitrogen fixation. |
| J. M. Joshi<br>Dept. of Soybean Research<br>Univ. of Maryland, Eastern Shore<br>Princess Anne, MD 21853 | Screening and breeding soybean varieties for insect resistance. |
| Robert C. Leffel<br>Room 236, Bldg. 007, BARC-W<br>USDA-ARS<br>Beltsville, MD 20705 | Breeding, genetics, and culture of soybeans. |
| Lowell D. Owens<br>Room 236, Bldg. 007, BARC-W<br>USDA-ARS<br>Beltsville, MD 20705 | Tissue culture of soybean for genetic improvement. |

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| Charles Sloger<br>Room 236, Bldg. 007, BARC-W<br>USDA-ARS<br>Beltsville, MD 20705 | Physiology of soybean-*Rhizobium* symbiotic $N_2$ fixation. |
| Deane F. Weber<br>Room 236, Bldg. 007, BARC-W<br>USDA-ARS<br>Beltsville, MD 20705 | *Rhizobium* research. Nodulation ecology of *Rhizobium japonicum*. |
| K. R. Bromfield<br>USDA-ARS<br>Plant Disease Research Lab.<br>P.O. Box 1209<br>Frederick, MD 21701 | Soybean rust. Soybean pathogens nonendemic to USA. Evaluation of pathogens for damage potential and study of their epidemic behavior. |
| Joseph G. Wutoh<br>Vice Chancellor for Academic Affairs<br>Univ. of Maryland, Eastern Shore<br>Princess Anne, MD 21853 | Breeding for insect resistance in soybean; breeding for physiological (photoperiodic) responses in soybean. |
| Alfred W. Saettler<br>Research Plant Pathologist<br>Bean Diseases Investigations<br>Michigan State University<br>East Lansing, MI 48824 | Primary research is in area of bean (*Phaseolus vulgaris* L.) diseases. |
| Willard A. Dickerson<br>USDA-ARS, P.O. Box A<br>Biological Control of Insects<br>Columbia, MO 65201 | Host plant resistance. |
| J. C. Graham<br>Agricultural Research<br>Monsanto Company<br>800 N. Lindbergh Blvd.<br>St. Louis, MO 63166 | Yield enhancement in soybeans via physiological modifications. |
| G. L. Eilrich<br>Agricultural Research<br>Monsanto Company<br>800 N. Lindbergh Blvd.<br>St. Louis, MO 63166 | Yield enhancement in soybeans via physiological modifications. |
| C. A. Porter<br>Agricultural Research<br>Monsanto Company<br>800 N. Lindbergh Blvd.<br>St. Louis, MO 63166 | Yield enhancement in soybeans via physiological modifications. |

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| James E. Specht<br>Dept. of Agronomy<br>347 Keim Hall<br>University of Nebraska<br>Lincoln, NE 68520 | Soybean breeding and physiology. |
| Y. T. Kiang<br>Dept. of Plant Science<br>University of New Hampshire<br>Durham, NH 03824 | Genetics and breeding of soybeans for cool climate. |
| Baldev K. Vig<br>Dept. of Biology<br>University of Nevada<br>Reno, NV 89507 | Somatic crossing over and somatic mosaicism in Glycine max: Development of a test system for study of mutagens. |
| Sam C. Anand<br>McNair Seed Company<br>P.O. Box 706<br>Laurinburg, NC 28352 | Breeding for nematodes and phytophthora root rot resistance in soybeans. |
| Judith F. Thomas<br>Dept. of Soil Science<br>2006 Gardner Hall, Phytotron<br>North Carolina State Univ.<br>Raleigh, NC 27607 | Growth of soybeans in controlled environments. |
| Joel Hudgins, Manager<br>FFR Southeastern Research Sta.<br>c/o FCX Service<br>Box 3847, W. Florence Station<br>1600 W. Darlington Street<br>Florence, SC 29501 | Varietal development for member cooperatives. Breeding for yield, adaptation and disease resistance. |
| Larry Davis, Manager<br>FFR Mid-South Research Station<br>R.R.#3, Box 40<br>Covington, TN 38019 | Varietal development for member cooperatives. Breeding for yield, adaptation and disease resistance. |
| D. E. Foard<br>Biology Division<br>Oak Ridge National Lab.<br>P.O. Box Y<br>Oak Ridge, TN 37830 | Mutagenesis for storage proteins and methionine content. |
| Randolph R. Henke<br>Comparative Animal Research Lab.<br>1299 Bethel Valley Road<br>Oak Ridge, TN 37830 | Mutagenesis-crop improvement, involving soybeans; selection of mutant lines of crop plants capable of producing large quantities of essential amino acids. |

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| Raymond D. Brigham<br>Texas Agr. Exp. Sta.<br>Route 3<br>Lubbock, TX 79401 | Breeding and varietal development for dryland and irrigated production; genetics of disease resistance. |
| Robert A. Nilan<br>Program in Genetics<br>Washington State Univ.<br>Pullman, WA 99163 | Chemical mutagenesis. |
| Deane C. Arny<br>Dept. of Plant Pathology<br>University of Wisconsin-Madison<br>1630 Linden Drive<br>Madison, WI 53706 | Diseases of soybeans and disease resistance. |
| Earl T. Gritton<br>Dept. of Agronomy<br>University of Wisconsin<br>Madison, WI 53706 | Soybean breeding and genetics. |

# IX. MAILING LIST

## ARGENTINA

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